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Learning to read and write polysyllabic words: the effects of morphology and context on the acquisition of whole-word representations in fourth and fifth grade

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LEARNING TO READ AND WRITE POLYSYLLABIC WORDS:
THE EFFECTS OF MORPHOLOGY AND CONTEXT ON THE ACQUISITION OF WHOLE-WORD REPRESENTATIONS IN FOURTH AND FIFTH GRADE

by

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DEDICATION

This Dissertation is dedicated to my parents, Zahra and Ahmed.

For their continuing support and countless sacrifices

Forever I shall remain indebted to you

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ABSTRACT

Accurate and rapid word recognition requires highly-specified phonological, orthographic, and semantic word-specific representations. It has been established that children acquire these representations through phonological decoding in a process known as orthographic learning. Studies examining orthographic learning and its predictors have thus far focused on monosyllabic words. It is unclear whether the findings of these studies—especially, those related to the role phonological decoding, orthographic knowledge, and contextual semantic information play in orthographic learning—can be generalized to polysyllabic words. A large number of the polysyllabic words children encounter in content-area texts is morphologically complex. Yet, examining the role of morphology in the orthographic learning of polysyllabic words is still in its infancy. The purpose of this study was to examine the role of morphology and context (two sources of semantic information) in the acquisition of whole-word representations of polysyllabic words in children with and without reading difficulty.

A total of 73 fourth and fifth grade children participated in this study. The children read 12 disyllabic pseudowords presented in isolation or in context. An orthographic choice task and a spelling task measured children's orthographic learning three days later. A battery of standardized and researcher designed tests measured children's phonological decoding skill, orthographic knowledge, and morphological knowledge. Data were analyzed using mixed-design analysis of variance and multiple linear regression.

The results of this study showed that morphology facilitated the orthographic learning of polysyllabic words in the spelling task but not in the orthographic choice task. The results also showed that context interfered with the orthographic learning of polysyllabic words, irrespective of their morphological structure. Context interference appeared to vary by children's reading skill—that is, context appeared to interfere with the orthographic learning of polysyllabic words in struggling readers and children with reading difficulty but not in typically achieving children. The results also showed that, controlling for phonological decoding and orthographic knowledge, morphological knowledge contributed to the orthographic learning of polysyllabic words, irrespective of children's reading skill. Implications for polysyllabic word reading instruction are discussed.

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GLOSSARY

I

irregular words

Irregular words are words that cannot be read following the regular letter-sound conversion rules in English (e.g., *yacht*).

M

morphological knowledge

In the literature, the terms *morphological awareness* and *morphological processing* are used, often interchangeably, to describe morphological skills that children use when reading polymorphemic words. Nagy, Carlisle, and Goodwin (2014) distinguished between the two terms. Nagy et al. (2014) defined *morphological awareness* as "the ability to reflect on and manipulate morphemes [or] the ability to analyze words into smaller meaningful parts such as prefixes, roots, and suffixes." (p. 4) and *morphological processing* as the unconscious (or tacit) use of morphology that underlies morphological awareness. In this study, similar to Nagy et al. (2014), the term *morphological knowl*edge is used "as a superordinate that covers morphological awareness and morphological processing (i.e., the tacit use of morphology)" (p. 4).

O

orthographic learning

Orthographic learning is “the process by which children move from decoding alphabetically to reading via the fluent recognition of individual words” (Castles & Nation, 2006, pp. 151–152). In this study, the term *orthographic learning* is used to refer to the acquisition of whole-word representations via phonological decoding.

orthographic knowledge

There is no consensus in the literature on the definition of the term orthographic knowledge and the tasks used to assess it. In this study, the term orthographic knowledge is used to refer to the ability to form and store whole-word representations (the spelling of the word) as well as the explicit and implicit knowledge of the structure of the orthography and the permitted orthographic units and patterns (e.g., double consonant letters *ll* may occur at the end but not at the beginning of an English word, *dill* vs. *llid*; Apel, 2011, Stanovich & West, 1989).

P

phonological decoding

Phonological decoding refers to reading words through the process of grapheme-phoneme (letter-sound) conversion. That is, reading words through mapping the individual letters (or letter clusters) in the word to their corresponding sounds and then blending them to pronounce the word.

CHAPTER ONE: INTRODUCTION

1.1 Background and Rationale

1.1.1 Importance of Polysyllabic Words

As children advance in the primary and secondary grades, they encounter an increasing number of polysyllabic words (Hiebert, Martin, & Menon, 2005; Kearns et al., 2016; Renaissance Learning, 2014; Zeno, Ivens, Millard, and Duvvuri, 1995; see Figure 1). Polysyllabic words are especially prevalent in content-area texts and often carry the critical meaning in text (Pedrotty Bryant, Ugel, Thompson, & Hamff, 1999)—and thus, difficulties in reading them could negatively impact reading comprehension.

Polysyllabic words are linguistically and orthographically complex and reading them, even for the skilled reader, could be challenging. Texts with a large number of polysyllabic words could place higher task demands for word recognition and lead to greater reading difficulties (Hiebert & Fisher, 2007), especially that polysyllabic words "are not repeated frequently within or across texts" (Hiebert et al., 2005, p. 18). The relative low-frequency of polysyllabic words may decrease the likelihood of children reading

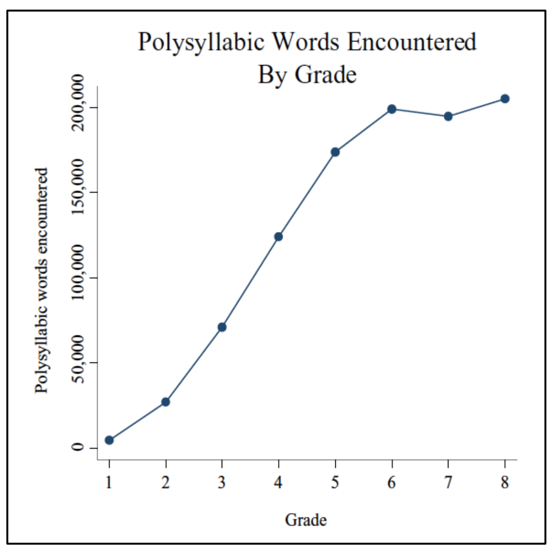

Figure 1: Kearns et al.'s (2016) illustration of the dramatic increase in the number of polysyllabic words school children encounter in content-area text (Kearns et al., 2016, p. 2).

them through direct access to whole-word representations and increase the difficulty of reading them for developing readers (Hiebert et al., 2005). Indeed, studies examining the relation between the number of polysyllabic words in text and text difficulty level have shown that the percentage of polysyllabic words in text is negatively associated with text readability level. In other words, higher percentages of polysyllabic words are associated with lower text readability levels (e.g., Benjamin, 2012; Compton, Appleton, & Hosp, 2004). Lower text readability levels are in turn associated with lower reading performance (Amendum, Conradi, & Hiebert, 2017; Hiebert & Fisher, 2007).

Given the documented relation between polysyllabic words and text difficulty level, if not equipped with effective and efficient polysyllabic word reading strategies, children could be at significant disadvantage, especially when attempting to comprehend a text. Automatic and fluent polysyllabic word recognition can reduce the cognitive demands of reading and provide children with greater opportunity to focus on the meaning in the text (LaBerge & Samuels, 1974; Perfetti, 1985).

1.1.2 Importance of Fluent Word Recognition

Reading is a complex task that involves multiple cognitive and linguistic processes. In its simplest definition, reading is the product of word recognition and language comprehension (Hoover & Gough, 1990). Skilled word recognition is one that is characterized not only by accurate pronunciation, but also by fluent and effortless pronunciation coupled with understanding of words' meaning. Fluent—accurate, automatic, and rapid—word recognition is considered the cornerstone of skilled reading, one that provides the reader with easy access to text meaning. Although reading comprehension is not only determined by the efficiency of word recognition alone (other factors like vocabulary, background knowledge, and text integration skills are likely to play a role; Yuill & Oakhill, 1991), there is broad consensus that word recognition is the gateway to and the first step towards reading comprehension. Therefore, polysyllabic word recognition was selected to be the focus of this study.

1.1.3 Sources of Difficulties in Polysyllabic Word Recognition

Polysyllabic words are more difficult to read than monosyllabic words. A primary source of difficulty in polysyllabic word reading is vowel pronunciation. When reading monosyllabic words, children often taught to make vowel pronunciation decisions based on the syllabic structure of the word—short vowel sound for closed syllable words (e.g., /ɛ/ in *bed*) and long vowel sound for open syllable words (e.g., /i/ in *be*). However, when reading polysyllabic words, children also have the option of reduced vowel sound, and have the daunting task of determining the accurate vowel pronunciation (short, long, or reduced) for each vowel in the word, based on its syllabic structure and the stress pattern. Following the same approach used to read monosyllabic words, children must follow a multistep process in order to read a new polysyllabic word. Children must first divide the word to individual syllables, determine the stress pattern in the word, determine the accurate vowel pronunciation in each syllable, blend the syllables to read the word as a whole, and then adjust the pronunciation (if needed) in order to arrive to the accurate whole-word pronunciation. Following these steps presents multiple challenges.

The first challenge children encounter when reading a new polysyllabic word is identifying the syllabic boundaries in the word or dividing it into its constituent syllables. Beginning readers are often taught a list of syllable types (e.g., close syllable, open syllable, silent *–e* syllable, controlled *–r* syllable, and consonant *–le* syllable) and a set of syllable division rules (e.g., dividing between two middle consonants, dividing before a single middle consonant). In addition to being highly cognitive and possibly inefficient, the application of syllable division rules may be unreliable as the syllable division rules are often violated. For example, one of the commonly taught syllable division rules is dividing a word after the first vowel and assigning a long vowel sound to the first (open) syllable and a short vowel sound to the second (closed) syllable. This rule can be applied successfully to read the word *pilot: pi/lot*, however, it produces an inaccurate pronunciation when used to read the word *finish*, which can be read correctly only by dividing it after the second consonant in the word *finish: fin/ish*.

The second challenge children encounter is determining the accurate stress pattern in the word. Polysyllabic words usually contain one stressed syllable and one or more unstressed syllables, depending on their length (secondary stress may occur in words with more than two syllables; e.g., the first syllable in *information*: /ˌɪn-fər-ˈmeɪ-ʃən/). Similar to syllable division rules, stress placement rules are varied, complex, highly cognitive, and may also be violated. For example, one common stress placement rule is that stress is placed on the first syllable if the word is a disyllabic noun or adjective (e.g., *PURple*, *HAPpy*) and on the second syllable if the word is a disyllabic verb or preposition (e.g., *reLAX*, *beTWEEn*). However, some disyllabic words may be pronounced correctly with first syllable stress and second syllable stress (e.g., *PREsent* when the word is a noun and *preSENT* when the word is used as a verb).

The third challenge children encounter is determining the accurate reduced vowel sound. Once children identify a word's syllabic structure and stress pattern, they need to determine the accurate vowel pronunciation. Vowels in the English language tend to have multiple possible pronunciations, especially in unstressed syllables where the vowel sound is reduced, which exacerbates the already difficult task of determining the accurate vowel pronunciation. For example, assuming mastery in syllable division rules and stress placement rules, children must learn that the vowel letter *i* has at least six possible pronunciations: /aɪ/ in *minor*, /ɪ/ in *linen*, /i/ in *glorious*, /ɨ/ in *rabbit*, /ə/ in flexible, and /ɪ/ in *raisin* (Kearns & Al Ghanem, 2014).

The last challenge children encounter is blending the read syllables and adjusting their pronunciation in order to produce an accurate pronunciation of the whole polysyllabic word. When children blend a word's individual syllables, their blended pronunciation may only approximate the accurate whole-word pronunciation. Children must rely on their existing verbal vocabulary (or mental lexicon) to locate the word that the blended pronunciation approximates and adjust their pronunciation accordingly to produce a natural whole-word pronunciation. This step is highly impacted by the size of the children's verbal vocabulary and by the context in which the word is presented. If the newly read polysyllabic word is not a part of the child's verbal vocabulary or presented with no contextual information, she will be at a great disadvantage and my not produce an accurate pronunciation of the read polysyllabic word.

An additional source of difficulty when reading polysyllabic words is the morphological complexity of the words. Polysyllabic words can be divided into monomorphemic words (i.e., words that cannot be broken into smaller meaningful units; e.g., *pru-dent*, *vi-ta-min*, *cat-e-go-ry*) or polymorphemic words (i.e., words with multiple units of meaning, typically a base-word and one or more affixes e.g., *dis-count*, *re-fue-ling*, *re-new-abl-ity*). Nagy and Anderson (1984) estimated that 60% of the new words acquired by school age children are polymorphemic words. The large number of polymorphemic words children encounter suggests that a morphological rather than syllabic approach to reading polysyllabic words may be beneficial. However, polymorphemic words vary in their transparency and in the degree to which the knowledge of the base word or root can aide in identifying and reading a related word. Some morphological words are transparent (i.e., contain easily identifiable base word and affix(es), e.g., *dis-place*, *dis-place-ment*) but others are opaque (i.e., the spelling and the pronunciation of the base word or root have been modified, e.g., *divide-division*, *nature-natural*). Additionally, some polysyllabic words are pseudo-prefixed words (i.e., words that appear to prefixed but they are not; e.g., *pre-carious*, *re-gal*). These variations in morphological transparency and the existence of pseudo-prefixed words can make reading polysyllabic words through morphological analysis strategy challenging.

To summarize, at the forefront of the characteristics that make accurate and fluent polysyllabic word recognition challenging, especially for the developing reader, are: the varied and complex syllable division rules, the varied and complex stress placement rules, the variety in vowel pronunciations, and the variety in transparency among polymorphemic words.

1.1.4 Instructional Approaches to Teaching Polysyllabic Word Reading

Current instructional approaches to teaching polysyllabic word reading tend to focus on either a syllabication strategy (e.g., Gillingham & Stillman, 2014; Wilson, 2005) or a morphological decomposition strategy (e.g., REWARDS, Archer, Gleason, & Vachon, 2003; PHAST, Lovett, Lacerenza, & Borden, 2000). The syllabication strategy teaches children "a set of rules for dividing words into parts (syllables) which direct the reader to attend to visual cues such as the presence of double or single consonants within the word." (Archer, 1981, p. 7). Children use these syllable division rules to identify and pronounce the individual syllables in the word and then blend the syllables into a whole-word. The morphological decomposition strategy, however, teaches children a set of high-frequency roots and affixes which direct the reader to attend to the familiar parts in the word (with or without focus on meaning), peeling known affixes, reading the affix(es) and the root word, and then blending them into a whole-word.

Currently, there is no consensus on which of the two approaches is likely to be more beneficial for children learning to read polysyllabic words. Although most commonly used by teachers, the syllabication strategy is based largely on the theoretical knowledge of the structure of the English language and has very little empirical data that support it (Kearns & Al Ghanem, 2014). For a reading strategy to be effective and powerful, the strategy needs to work most of the time (Laberge & Samuels, 1974). And, as shown earlier syllable division rules can be unreliable and produce erroneous pronunciations (see example on page 4). In order to examine the reliability of the syllabication strategy, Kearns and Al Ghanem (in revision, a) analyzed 117,625 English words and their pronunciations (obtained from the Unisyn database, Fitt, 2001) and found that the reliability of the syllable division rule for disyllabic words with VCV pattern (e.g., *mi-nor, ma-jor*) varied by vowel identity and by the number of syllables in the word. The results of this analysis appear to support the observation of unreliable syllable division rules and bring into question the usefulness of teaching polysyllabic word reading through a syllabication strategy, especially that learning and applying syllable division rules can be cognitively demanding and can slow word pronunciation and access to meaning. It remains unclear, however, whether children use a syllabication strategy to acquire whole-word representations of polysyllabic words.

The morphological decomposition approach to teaching polysyllabic word reading appears to offer a promising alternative to the unreliable and inefficient syllabication strategy. A morphological strategy may be particularly appealing because of the large number of polysyllabic-polymorphemic words (Nagy & Anderson, 1984), and because of the converging evidence supporting the role of morphological awareness in word recognition and comprehension (e.g., Carlisle, 2000; Carlisle & Fleming, 2003; Deacon, Tong, & Francis, 2017; Kearns, 2015) and the efficacy of reading intervention programs that teach morphological decomposition strategies (e.g., Archer, 1981, Goodwin & Ahn, 2010; Goodwin & Ahn, 2013). However, a morphological decomposition approach to reading polysyllabic may be limited by the existence of polysyllabic-monomorphemic words and by the variety in morphological transparency among polymorphemic words. It is unclear whether a morphological decomposition approach influences the acquisition of whole-word representations. Yap and Balota (2015) noted that "[although] the ultimate goal of reading is to extract meaning from visually printed words, the influence of meaning-level influences on word recognition remains poorly understood" (p. 34). It remains unclear whether children use a morphological decomposition strategy to acquire whole-word representations.

1.2 Scope and Aims

This study was designed to examine whether morphology and context facilitate the orthographic learning of polysyllabic words, and whether these facilitating effects vary in children with and without reading difficulty. This study was also designed to examine whether morphological knowledge contributes to the orthographic learning of polysyllabic words. This study aimed to answer two central research questions:

Research Question #1: Do children acquire higher quality whole-word representations of printed polysyllabic words when presented in context and with an emphasis on morphemes, versus in isolation and with an emphasis on syllables? Do the patterns of acquisition vary by children's reading skill?

Research Question #2: Does morphological knowledge contribute to the acquisition of whole-word representations of printed polysyllabic words, in the presence of phonological decoding skill and orthographic knowledge? Do these contributions vary based on children's reading skill?

In designing this study, it was hypothesized that the semantic information provided by morphemes and context would facilitate the acquisition of higher quality whole-word representations of polysyllabic words. Morphemes (roots and affixes) and context would contribute to the meaning of the words and strengthen the connections between their meaning, pronunciation, and spelling; and lead to higher-quality representations that allow for accurate and rapid word recognition in subsequent encounters. It was also hypothesized that the facilitating effects of morphemes and context would vary by children's reading skill. Children with reading difficulty have poorer phonological decoding and morphological knowledge than their typically achieving peers, and tend to rely more on context to identify and pronounced words (Deacon, Tong, & Mimeau, 2016). Thus, smaller facilitating effects of morphology and larger facilitating effects of context in the acquisition of whole-word representations of polysyllabic words would be observed in children with reading difficulty.

Finally, it was hypothesized that morphological knowledge would contribute to the acquisition of whole-word representations of polysyllabic words. Children acquire whole-word representations through phonological decoding. As children become more skilled in reading, they use increasingly larger orthographic units (i.e., syllables and morphemes; Ehri, 2005, Frith, 1986). Given the increasing role of morphology in the decoding process, morphological knowledge would likely contribute to the acquisition of whole-word representations of polysyllabic words, even in the presences of phonological decoding and orthographic knowledge, two known predictors of the orthographic learning of polysyllabic words. The contributions of morphological knowledge would likely vary by children's reading skill. Given that children with reading difficulty have poorer morphological knowledge than their typically achieving peers, they would be less likely to read words using a morphological decomposition strategy, and morphological knowledge would contribute less to their acquisition of whole-word representations of polysyllabic words.

1.3 Overview of Methodology

This study is an orthographic learning study modeled after Share's (1999) self-teaching paradigm. Children enrolled in this study completed an orthographic learning task in which they read a set of 12 pseudo-disyllabic words: 6 monomorphemic and 6 dimorphemic. The children were randomly assigned to one of two study conditions: isolation or context. Children in the isolation condition read the target pseudowords as they completed a categorization task that required them to read the words one at a time and decide whether they were real or made-up words. Children in the context condition read the target pseudowords embedded in short stories. Children's orthographic learning was assessed three days later through two orthographic learning measures that require them to visually identify and reproduce the target words: an orthographic choice task and a spelling task, respectively. Children also completed a set of measures of phonological decoding skill, orthographic knowledge, and morphological knowledge.

To answer the first research question concerning the facilitating effects of morphology and context on the acquisition of polysyllabic words, children's composite orthographic learning score as well as their scores on the individual orthographic learning measures were examined using mixed-design analysis of variance (ANOVA). To answer the second research question concerning the unique contribution of morphological knowledge in the acquisition of polysyllabic words, children's scores were examined using multiple linear regression models.

1.4 Relevant Previous Research

1.4.1 Modeling Word Recognition

One of the most prominent models of word recognition is Seidenberg and McClelland's (1989) parallel distributed processing (PDP) model known as the connectionist model. According to this model, accurate word recognition is the result of the simultaneous activation of word-specific phonological representations (pronunciation), orthographic representations (spelling), and semantic representations (meaning; see Figure 2). In the early stages of learning to read in alphabetic writing systems such as English and Dutch, children learn to use language-specific grapheme-phoneme (or letter-sound) conversion rules to pronounce words in a process known as phonological decoding. Once children have developed strong word-specific

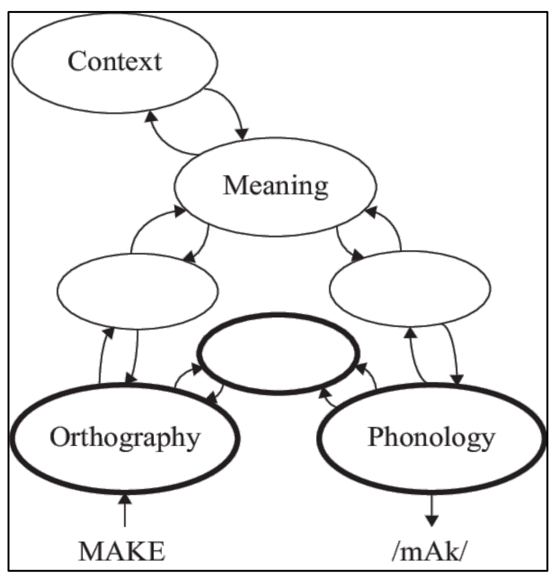

Figure 2: Seidenberg and McClelland's (1989) Parallel distributed processing Model (Seidenberg & McClelland, 1989, p. 527).

representations, they begin to identify the words through direct visual word recognition and reserve phonological decoding for new words. In other words, a word can be recognized rapidly through its orthographic form when the reader possesses highly specified representations of its orthographic, phonological, and semantic constituents (Perfetti & Hart, 2002; Seidenberg & McClelland, 1989). In the field of word recognition, the process with which children transition from the slow and laborious process of phonological decoding to the automatic and rapid process of word recognition is termed *orthographic learning* (Castles & Nation, 2006).

1.4.2 Orthographic Learning through Self-Teaching Mechanism

One of the most influential hypotheses in orthographic learning is Share's (1995) *self-teaching* hypothesis. The self-teaching hypothesis posits that phonological decoding works as a self-teaching mechanism for learning word-specific orthographic representations necessary for direct visual word recognition. Share (1995) suggests that by using letter-sound conversion rules to decode new words, children's attention is drawn to the words' specific representations, such as the letters in the words, the order of the letters, and the way the letters map onto sound, which leads to the acquisition of whole-word representations that can be accessed through direct sight-word reading.

According to the self-teaching hypothesis, children's ability to self-teach and build word-specific orthographic representation relies primarily on their phonological decoding skills. Children's ability to self-teach is also believed to be determined by their orthographic knowledge. Consequently, skilled readers are more likely to be successful at orthographic learning through self-teaching mechanism than their peers with reading difficulty and poor phonological decoding and orthographic knowledge.

1.4.3 Individual Differences in Orthographic Learning

Studies that aimed to provide empirical evidence for orthographic learning via a self-teaching mechanism have indeed found that phonological decoding plays a critical role in orthographic learning in several languages, including English (e.g., Cunningham, 2006; Cunningham, Perry, Stanovich, & Share, 2002), Dutch (e.g., de Jong, Bitter, Van Setten, & Marinus, 2009; de Jong & Share, 2007), and Hebrew (e.g., Share, 1999; Share & Shalev, 2004). However, evidence for the role of orthographic knowledge in orthographic learning has been documented far less (e.g., Cunningham, 2006; Cunningham et al., 2002) and further studies are needed in order to shed more light on the role of orthographic knowledge in orthographic learning in English as well is in other languages.

One additional key component of the self-teaching hypothesis is context. Share (1995) argues that self-teaching is an unintentional process that takes place during reading natural text and that context aids this process. It is unintentional because “readers do not usually aim to analyze and remember spellings, it just happens and probably without [the reader] being aware of the process” (Share, 2008). Context aids this unintentional process by providing semantic information that allows children to resolve decoding ambiguities (Share, 1995). That is, when children are only able to provide partial decoding for a word, the semantic information in the text helps them search their mental lexicon for word candidates that have a pronunciation close to the partially decoded word and might make sense within the given context. For example, if a child reading the sentence *Sam sat on the chair* is not able to fully decode the word *chair*, she might search her mental lexicon for a word that begins with /tʃ/ and ends with /r/ that makes sense in the unknown word's location in the sentence. This should lead the child to select the word *chair* /tʃɛər/ rather than *cheer* /tʃɪər/ which does not make sense given the semantic information provided in the sentence. This process allows the child to connect the accurate pronunciation of the word to its spelling. In subsequent encounters of the word, the child will be able to access the word through direct visual recognition rather than phonological decoding. Though this hypothesis is outwardly compelling, empirical evidence is lacking. In fact, some studies (e.g., Cunningham, 2006; Landi, Perfetti, Bolger, Dunlap, & Foorman; 2006) examined the role of context in orthographic learning and failed to demonstrate any facilitating effects of context despite its central role in the self-teaching hypothesis.

Another semantics-related variable that has yet to be examined in the orthographic learning and self-teaching literatures is morphological knowledge. Although phonological decoding is not restricted to letter-by-letter decoding (large orthographic units such as syllables and morphemes are possible; Share, 1995; Ehri, 1992), orthographic learning studies across languages, especially English, have thus far focused on monosyllabic words (note that the Hebrew literature included multisyllabic words but did not examine morphology either; Share, 1999; Share 2004). Morphemes (affixes and roots) are unique in that they do not only provide phonological information, but also carry semantic and syntactic (grammatical) information that can aid the orthographic learning of unfamiliar words. Examining orthographic learning using polysyllabic-polymorphemic words (e.g., *re-charge* and *re-charge-able*) provides a unique opportunity to exploring the role morphemes play in the orthographic learning of more complex words. It allows for the examination of whether prior knowledge of one or more of the units of meaning (morphemes) in the unfamiliar word facilitates its orthographic learning.

To summarize, according to the self-teaching hypothesis, phonological decoding skills, orthographic knowledge skills, and semantic knowledge determine children's ability to self-teach and to form whole-word representations. It is important to understand the role of each of these components in orthographic learning in order to understand why some children succeed in building word-specific orthographic representations and can access words through their orthographic form after as few as one phonological decoding trial (Share, 2004) while others continue to use phonological decoding for the same words even after multiple encounters. Given that phonological decoding is the primary component of the self-teaching hypothesis, it is reasonable to predict that it is the primary source of individual differences in orthographic learning. That is, phonological decoding skill is what differentiates between children who succeed in acquiring functional word-specific orthographic representations and those who continue to use phonological decoding to identify words. Evidence supporting this hypothesis were reported by Share and Shalev (2004), and Wang, Marinus, Nickels, and Castles (2014).

Evidence for orthographic knowledge and semantic knowledge being sources of individual differences in orthographic learning has been far less documented. Notably, two studies (Share & Shalev, 2004; Wang et al., 2014) have provided evidence that the orthographic knowledge could explain individual differences in orthographic learning, even after accounting for phonological decoding skills. In fact, they pointed out a group of children who exhibited characteristics similar to those with surface dyslexia. Those children had adequate phonological decoding skills but failed to acquire word-specific orthographic representations due to their orthographic knowledge deficit. To date, no study has found semantic knowledge to be a source of individual differences in orthographic learning. More studies are needed to examine heterogeneity among children with poor orthographic learning skill.

1.5 Significance of the Study and Conclusion

To summarize, polysyllabic words constitute a large proportion of words middle and upper elementary school children encounter in text. These words are particularly difficult to read due to their unique orthographic and phonological characteristics. The number of polysyllabic words in a text determines the text readability level and accessibility to meaning. Children must be able to identify and pronounce polysyllabic words rapidly to access the meaning in text. However, it is unclear whether teaching polysyllabic word reading through syllabication strategy or morphological analysis strategy is more beneficial and whether it facilitates the acquisition of higher quality word representations. It is also unclear what role context plays in the acquisition of these representations. This study is designed to shed more light on the role morphology and context play in the acquisition of whole-word representations of polysyllabic words. The data obtained from this study may aid educators in their selection of reading instructional programs for advanced word study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview

The purpose of this chapter is to provide a brief summary of the current orthographic learning literature and to discuss gaps in the literature, as they relate to the orthographic learning of polysyllabic words. I begin by discussing evidence for orthographic learning through self-teaching mechanism in elementary school children. I then summarize studies that examined correlates and predictors of orthographic learning. Finally, I summarize studies that examined orthographic learning in children with reading difficulties.

2.2 Evidence for Orthographic Learning through Self-Teaching Mechanism

According to the self-teaching hypothesis proposed by Share (1995), phonological decoding functions as a self-teaching mechanism for unfamiliar words encountered in text. Phonological decoding of newly encountered words draws the reader's attention to the orthographic details of the words and leads to the formation of word-specific orthographic representations necessary for rapid visual word recognition. A small number of studies tried to provide evidence for this hypothesis since it is recent inception. I summarize some of these studies and their findings in this section.

The earliest evidence for orthographic learning through self-teaching came from Share (1999). In four experiments, Share (1999) assessed orthographic learning in second grade Hebrew-speaking children ($N = 40$). Children read aloud ten short stories presented in pointed Hebrew. Each story contained a target pseudoword repeated four or six times. These pseudowords represented nouns (i.e., names of places, animals, fruits, etc.). The accuracy of the pronunciation of the pseudowords was recorded but no corrective feedback was provided. Children read the target pseudowords with 84.4% accuracy. Children's learning of the pseudowords was measured three days later using an orthographic choice task, a naming task, and a spelling task. The orthographic choice task required children to select the target pseudowords from sets of four words (the target pseudoword, a homophone foil, a visually similar pseudoword, and the target pseudoword with transposed letters; e.g., *daif*, *dafe*, *dait*, *diaf*). The naming task required children to read lists that included the target pseudowords, their homophone foils, and real words. The spelling task required children to write the target pseudowords as the tester dictated them.

The orthographic choice task results showed that children selected the target words with accuracy rates well above chance level (above 65%). The spelling results also showed rates above chance (above 50%). The children's performance on these two tasks did not vary based on the number of times they were exposed to the target words (four vs. six), indicating that four exposures are sufficient to form functional word-specific orthographic representations. The naming task results, however, failed to show evidence for orthographic learning. Children read the target pseudowords and their homophones with comparable accuracy and speed. The lack of differences in the accuracy and naming latency data may be attributed to the regularity of the pointed Hebrew script—a highly regular script characterized by "near perfect one-to-one grapheme-phoneme correspondence." (Share, 1999, p. 103).

Although the results of this experiment suggested that children's phonological decoding leads to the retention of the word's orthographic form, another explanation was also possible. Namely, the learning of the target pseudowords could be the result of visual exposure rather than phonological decoding. To assess this possibility, Share (1999) carried out a subsequent experiment in which he manipulated the degree to which phonological decoding was permitted during pseudoword reading. The results showed that experimental manipulations that reduced phonological decoding lead to decreased rates of orthographic learning, which clearly supports the hypothesis that orthographic learning is the product of phonological decoding proposition.

Additional evidence for orthographic learning through self-teaching mechanism in Hebrew was reported in Share (2004). In this study, Share (2004) used methods similar to those described in Share (1999) but manipulated the number of times the target pseudowords were presented in the story (1, 2, or 3 presentations) and the length of the duration between sessions (3, 7, and 30 days). Share's (2004) study showed that, at least for third grade Hebrew-speaking children (*N* = 36), one exposure is sufficient to produce reliable orthographic learning and that this learning was maintained 30 days later. Again, evidence of orthographic learning was robust in the orthographic choice task and the spelling task but not for the naming task owning to the regularity pointed Hebrew. In two subsequent experiments, Share (2004) used the same methods to examine orthographic learning in first grade children (samples 32 and 64). The two experiments failed to show any evidence of orthographic learning in this younger group of children. Notably, children had decoding accuracy rates above 75% but did not demonstrate orthographic learning even when the targets were real words and were repeated eight times during the orthographic learning task. This finding suggests that beginning Hebrew readers are insensitive to orthographic details, and that they read in a manner that resembles surface dyslexia—that is, their reading characterized by adequate decoding skills but poor whole-word recognition. For Hebrew speaking children, the ability to use phonological decoding as a self-teaching mechanism appears to commence in second grade.

Orthographic learning through self-teaching mechanism in first through third grade children was also observed in English speaking children. Cunningham (2006) examined orthographic learning in 35 first grade children using the standard self-teaching study design Share (1999) and Share (2004) used but manipulated the type of words used as targets (real words and pseudo-homophones; e.g., *piece* and *peece*; respectively) and the stories contained six repetitions of the target words. Cunningham (2006) measured children's orthographic learning three days after story reading using an orthographic choice task and a spelling task. During story reading, children read the target words with high levels of accuracy (average accuracy rate of 75.3%). Cunningham (2006) observed evidence for orthographic learning in the orthographic choice task (average accuracy rate of 49.29%) but not in the spelling task. The orthographic choice results suggest that, unlike younger children learning to read in Hebrew, younger children learning to read in English are sensitive to the orthographic details of words. It is possible that the irregularities in the English language encourage children to pay attention to the orthographic details of the words while the reliability of the grapheme-phoneme correspondences in Hebrew encourages children to continue to use serial decoding to identify words. The spelling findings, however, are consistent with those observed in Hebrew for the same age group reported in Share (2004). The null spelling results may be caused by the difficulty of the task. While the orthographic choice task requires visual identification of the target word's form, the spelling task requires the retention and the reproduction of that form. It is possible that the functionality of the newly acquired word form did not extend to those high-level skills.

Orthographic learning in second grade children ($N = 34$) was examined by Cunningham, et al. (2002). Children read target pseudowords embedded in short stories. The target pseudowords were repeated six times in the text and children's orthographic learning was measured three days after story reading using an orthographic choice task, a naming task, and a spelling task. The average accuracy rate for the decoding of the target pseudowords was 74%. Evidence for orthographic learning was observed in the orthographic choice task (average accuracy rate of 74.7%) and in the spelling task (average accuracy rate of 70.3%). No reliable orthographic learning was observed in naming accuracy (average accuracy rates for targets and homophones were 82% and 80%, respectively). However, targets were read faster than homophones (average difference 41ms; $p < .025$). These findings suggest that second grade children learning to read in English are capable of self-teaching new word forms.

Bowey and Muller (2005) examined orthographic learning using the self-teaching paradigm in 63 third graders. The stories used contained four or eight repetitions of the target pseudoword. Children's orthographic learning was measured immediately after story reading (no-delay condition) and six days later (delay condition) using an orthographic choice task and a list-reading task. The results of the orthographic choice task showed that, generally, children selected the target words more often than the homophone foils ($F(1,53) = 6.49$, $p = .014$), with more accurate identification of the target words in the eight repetitions condition and the no delay condition. The results of the list-reading task showed that the list of the target pseudowords was read faster than the homophone list ($F(1,52) = 17.96$, $p < .001$), irrespective of the number of target repetitions and session delay condition.

To sum up, the current self-teaching literature provides evidence for orthographic learning through self-teaching mechanism for children learning to read in highly regular languages (Hebrew) and less regular languages (English). Both groups of children showed high levels of phonological decoding and orthographic learning, especially in the orthographic choice task and the spelling task. It appears that children learning to read in English develop orthographic sensitivity earlier than children learning to read in Hebrew. The evidence for orthographic learning in younger children in English, however, was only observed in the orthographic choice task, and may be influenced by differences in early reading instruction in the two languages. Notably, the items used in the Hebrew studies were two-four syllable pseudowords while the items used in the English studies tended to be simple monosyllabic words. It is not clear how this difference might have influenced the patterns of orthographic learning in English. English polysyllabic words contain more irregularities than monosyllabic words and may be harder to acquire through a self-teaching process.

2.3 Correlates and Predictors of Orthographic Learning

Share's (1995) description of the self-teaching hypothesis suggests that orthographic learning is influenced by children's phonological decoding skills and orthographic knowledge as well as their ability to use the semantic information in the text to resolve phonological decoding ambiguities. Share (1995) argued that the phonological decoding skill is the cornerstone of orthographic learning, and even though orthographic knowledge and semantic knowledge are important, they play a secondary role in orthographic learning. The early version of the self-teaching hypothesis maintained that orthographic learning is the result of successful effortless phonological decoding, and that slow effortful phonological decoding detracts from the ability to pay attention to the orthographic details of the words (Share, 1995). However, Share (2008) later noted that children may be able to acquire word-specific orthographic representations in the absence of accurate phonological decoding. He suggested that attempting to phonologically decode unfamiliar words might be sufficient for successful orthographic learning. Nevertheless, he maintained that orthographic learning is closely related to accurate phonological decoding skills, and that orthographic knowledge and semantic knowledge are secondary to successful orthographic learning. In this section, I summarize the findings of studies that examined the relation between phonological decoding skills, orthographic knowledge, and semantic knowledge and orthographic learning.

2.3.1 Phonological Decoding and Orthographic Knowledge Effects in Orthographic Learning

The contribution of phonological decoding skills to orthographic learning was examined by Ricketts, Bishop, Pimperton, and Nation (2011). In this study, 88 children (aged 7–8 years) read short stories that included four repetitions of target pseudowords. Next, children completed filler (unrelated) task followed by an orthographic choice task and a spelling task that assessed their learning of the target pseudowords. Additionally, children completed the *Sight Word Efficiency* and the *Phonemic Decoding Efficiency* subtests of the *Test of Word Reading Efficiency* (TOWRE; Torgesen, Wagner, & Rashotte, 1999), a reading comprehension test (*Neale Analysis of Reading Ability-II*; Neale, 1997), and the vocabulary subtest of *Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler, 1999). Ricketts et al. (2011) used these measures to predict orthographic learning after controlling for children's nonverbal reasoning (as measured by the *Matrix Reasoning* subtest of WASI; Wechsler, 1999) and target pseudowords decoding. The measures were entered one at a time into separate hierarchical regression models. The results showed that nonverbal reasoning explained a small but significant portion of the variance in orthographic choice (8%; $p < .01$) but was not a significant predictor of spelling. In all models, target pseudowords decoding explained a significant portion of the variance in orthographic learning (10% in orthographic choice and 28% in spelling; $p < .01$ and $p < .001$, respectively). None of the other variables made a significant contribution to either orthographic learning index. These results clearly indicate that phonological decoding plays an important role in orthographic learning though a large portion of the variance in orthographic learning remains unexplained.

The independent contribution of both phonological decoding and orthographic knowledge in orthographic learning was also examined in Cunningham et al.'s (2002) study described earlier (see page 23). The authors used target pseudowords decoding to estimate the second graders' phonological decoding skill and an abbreviated version of Olson, Kliegl, Davidson, and Foltz's (1985) orthographic choice task to estimate their orthographic knowledge. The task required children to select the word that represent an accurate spelling of an English word from pairs of homophones (e.g., *rume-room*). The authors then used hierarchical regression models to predict orthographic learning as measured by a composite score of the three posttest measures: orthographic choice, naming, and spelling. The regression models showed that target pseudowords decoding and orthographic knowledge combined explained 69% of the variance in orthographic learning ($p < .01$), and that the orthographic knowledge had a unique contribution of 20% ($p < .01$). It is worth noting that in two additional regression models Cunningham et al. (2002) also examined whether general cognitive ability (as measured by a receptive vocabulary test, a pseudoword reading test, an auditory memory test, and a nonverbal ability test) and rapid automatized naming (as measured by color, letter, and digit naming) contributed to orthographic learning. In both analyses, only target pseudowords decoding contributed to orthographic learning. Neither general cognitive ability nor rapid naming made a unique contribution to orthographic learning. These results strongly suggest that orthographic learning relies largely on children's phonological decoding skills and that orthographic knowledge plays an important role in the orthographic learning process.

Cunningham's (2006) study described earlier (see pages 22 and 23) also examined the independent contribution of phonological decoding and orthographic skills in orthographic learning in first grade. The author measured children's phonological decoding skill using the *Word Attack* subtest of the *Woodcock Reading Mastery Test–Revised* (Woodcock, 1987), and children's orthographic knowledge using a composite score of three orthographic knowledge tests. The orthographic knowledge tests included an abbreviated version of Olson et al.'s (1985) orthographic choice task, Cassar and Treiman's (1997) letter string task, and Stanovich and West's (1989) homophone knowledge task. The letter string task required children to identify the letter string that most resembles a real English word from pairs of pseudowords (e.g., *lape-laip*). The homophone knowledge task required children to listen to short questions and select the word that represents the correct spelling of a possible answer from pairs of homophones (e.g., *"which is a flower? rows or rose"*). Cunningham (2006) used hierarchical regression models to analyze the data and showed that orthographic knowledge made a unique contribution to orthographic learning estimated using a composite score of the posttest orthographic choice and spelling tasks. After accounting for phonological decoding skill, orthographic knowledge explained additional 11% of the variance in orthographic learning. These results as well as the nonsignificant contribution of general cognitive ability and rapid automatized naming to orthographic learning are consistent with the findings of Cunningham et al. (2002). Together, the findings of these two studies strongly suggest that both phonological decoding skill and orthographic knowledge make independent and unique contributions to orthographic learning.

On the whole, it appears that orthographic learning is influenced by both word-specific phonological decoding skills (Rickett et al., 2011; Cunningham et al., 2002) and general phonological decoding skills (Cunningham, 2006). However, when both word-specific and general phonological decoding skills are entered to regression models, only word-specific phonological decoding accounts for a significant variance in orthographic learning (Ricketts et al., 2011). One possible explanation for this finding relates to Share's (1995) assertion that the development of word recognition is an item-base rather than a stage-base process. Share (1995) argues that it is not general skills that account for word recognition; it is rather the knowledge of the specific word's orthographic, phonological, and semantics representations (a view aligned with Seidenberg & McClelland's, 1989 PDP model). Another possible explanation is that word-specific phonological decoding is a proxy of general phonological decoding skill and that the two measures assess the same underlying skill. However, it is worth to mention that in a recent descriptive study, Al Ghanem and Kearns (2014) examined the role of general skills and word-specific knowledge in word recognition and found that both types of skills made unique contributions to polysyllabic word recognition.

2.3.2 Semantic Knowledge Effects in Orthographic Learning

The contribution of semantic knowledge to orthographic learning was examined in a number of studies that varied in their conceptualization of the semantics component of the self-teaching hypothesis and the semantic information that are likely to influence orthographic learning. While some studies examined the effects of the semantic information provided by context in on orthographic learning, others examined the effects of the semantic information provided through word-level semantics—namely word-meaning and, more scarcely, morphemes. The findings of these studies are summarized below.

2.3.2.1 Semantic Knowledge Effects in Orthographic Learning: Context and Word-Meaning

In order to examine the role of context in orthographic learning, Ricketts et al. (2011; a study described on page 26) presented their target pseudowords in one of two types of stories: general context stories or specific context stories. The stories in the general context condition provided ambiguous cues to the meaning of the target pseudoword (i.e., they indicated the category of the pseudoword; e.g., *an animal*). The stories in the specific context condition provided cues that indicated the exact meaning of the pseudoword (e.g., *a giraffe*). Ricketts et al. (2011) compared children's orthographic learning in the two conditions using one-way ANOVA. The results of the analyses for both the orthographic choice task and the spelling task showed no significant main effect of context (Fs ≤ 1, ps $> .05$), indicating that the semantic information provided by context did not facilitate orthographic learning.

Ricketts et al.'s (2011) findings replicate the findings of Nation, Angell, and Castles (2007) who examined the effects of context on orthographic learning in 42 third and fourth grade children. The children read target pseudowords presented one, two, or four times in context or in isolation. The design of the context condition followed Share's (1999) self-teaching design. The isolation condition required children to complete a categorization task in which they read words presented on cards and determined whether they were real words or made-up words. Nation et al. (2007) measured the children's learning of the target pseudowords one day and seven days later using an orthographic choice task. They used ANOVA to examine differences in orthographic learning related to context and session delay. The analyses showed no significant main effect or interaction of context (Fs ≤ 1, ps $> .05$), suggesting that children did not benefit from the semantic information provided in the context condition.

Cunningham (2006; a study described on pages 22–23) also examined whether semantic and syntactic information provided by context facilitate orthographic learning in first grade children by adding a no-context condition to her experiment. In this condition, children read the target real words and pseudo-homophones in scrambled short stories in which the order of the words was altered and punctuation marks were removed. Cunningham (2006) compared the rates of target word decoding in the two conditions and showed that context facilitated children's decoding of the target words. That is, children decoded more target words correctly in the context condition than they did in the no-context condition (83.6% and 67%, respectively, $p < .001$). However, when she compared the levels of orthographic learning in the two conditions using chi-squared tests, she found no significant differences in the scores of the orthographic learning measures based on the context conditions. On average, children had 49.29% accuracy rate on the orthographic choice items presented in context and 46.43% accuracy rate on the items presented in scrambled stories (p = .75). Similarly, children had 36.43% accuracy rate on the spelling items presented in context and 25% on the items presented in scrambled text. Again, the results of this study indicated no facilitating effects of context in orthographic learning.

The findings of Cunningham (2006) echoed the findings of Landi et al. (2006) who used a modified version of the self-teaching design to assess the relation between context and orthographic learning in kindergarten through second grade. Landi et al. (2006) presented children with a set of real words in one of two conditions: context or isolation. The context condition required children to read the last word in a two-sentence paragraph read by the examiner. The isolation condition required children to read the target words printed on cards and presented one at a time. In both conditions, the target words were bolded and underlined. The children completed the posttest (a target word naming task) one week later. Landi et al.'s (2006) examination of the differences in orthographic learning between the two conditions revealed that (similar to Cunningham, 2006) context facilitated target word decoding but did not facilitate the retention of the form of the target words. In fact, Landi et al. (2006) reported that children were more likely to retain the form of the target words when they were presented in isolation, indicating that context may detract from the attention paid to word's orthographic details and prohibit orthographic learning.

The role of semantics in orthographic learning was also examined in a number of orthographic learning studies that adopted a modified self-teaching study design that included a training phase in which children were provided with a short definition or description for the target pseudoword, a picture representing the target pseudoword, or a combination of the two. The children then participated in a series of sessions in which they practiced reading, and sometimes writing, the target pseudowords followed by completing measures of orthographic learning. One such study is Ouellette and Fraser's (2009) study. A total of 44 fourth grade children participated in this study. The children completed an orthographic learning task that required them to read a set of pseudowords presented in one of two conditions: semantic or orthographic.

In the semantic condition, the experimenter read the target pseudowords, one at a time, and asked the children to repeat them. For each target pseudoword, the experimenter provided a definition and a drawing representing it. The children then practiced reading the target pseudowords and matching them to their pictures and the experimenter provided corrective feedback as necessary. In the orthographic condition, the experimenter read the target pseudowords and asked the children to repeat them. The experimenter paused after each word and instructed the children to think about the pseudoword for about 20 seconds before presenting the next pseudoword. The children then practiced reading the target pseudowords and a set of real words, and completed a categorization task that required them to determine whether the word they read was a real word or a made-up word. Ouellette and Fraser (2009) measured children's orthographic learning using an orthographic choice task and a spelling task, and examined whether children's orthographic learning varied by the condition in which the target pseudowords were practiced using repeated measures ANOVA. The results of the analysis yielded a main effect of condition, favoring the semantic condition, in the orthographic choice task, $F(1, 34) = 4.67$, $p < .05$, but not in the spelling task, $F(1, 34) < 1$, $p > .05$. The results of this study indicate short definitions and illustrations facilitate orthographic learning, as measured by orthographic choice task.

Ouellette (2010) used the same training procedure used in Ouellette and Fraser (2009) to examined the effects of semantic in orthographic learning in a group of 36 second grade children. Ouellette (2010), however, included two types of training: reading and spelling. Half of the children in the semantic condition and half of the children in the orthographic condition practiced reading the target pseudowords, and the other half practiced writing them. Children's orthographic learning was measured using a spelling task. Analyzing the orthographic learning data using multivariate analysis of variance (MANOVA) models, Ouellette (2010) showed a significant main effect of condition, $F(1, 34) = 4.70$, $p < .05$, favoring the semantic condition, irrespective of practice-type (reading vs. spelling). Clearly, the findings of this study indicate that short definitions and illustrations provide semantic information that facilitate orthographic learning.

Wang, Castles, Nickels, and Nation (2011) also examined the effects semantics in orthographic learning. In two experiments ($N = 19$ and $N = 22$), Wang et al. (2011) incorporated two sources of semantic information, contextual information and word-meaning. In both experiments, second grade children completed an orthographic learning task that required them to read a set of pseudowords, half of which embedded in short stories and half presented in isolation. The target pseudowords were assigned a regular pronunciation in the first experiment and an irregular pronunciation in the second experiment (e.g., the pseudoword *cleap* was assigned the regular pronunciation /kli:p/ in the first experiment and the irregular pronunciation (/kleIp/ in the second experiment; Wang et al., 2011). Prior to completing the orthographic learning task, the children practiced reading the targets pseudowords, studied their definitions, and saw drawings representing them. Children's orthographic learning was assessed using three orthographic learning measures: an orthographic choice task, a spelling task, and an orthographic decision task. The orthographic choice task and the spelling task were similar to those used in traditional orthographic learning and self-teaching studies. The orthographic decision task required the children to determine whether a visually presented pseudoword had the same pronunciation and spelling as one of the previously learned pseudowords. The data obtained from the two experiments were analyzed using repeated measures ANOVA models. The analyses in the first experiment did not show significant effects context in any of the orthographic learning measures, $F \leq 2.71$, $p \geq .73$. The analyses in the second experiment showed no significant effects of context in the spelling or the orthographic choice task, $F \leq 1.02$, $p \geq .89$. They, however, showed a significant main effect of context in the orthographic decision task, $F(1, 20) = 8.65$, $p = .01$, favoring the context condition. The results of these two experiments suggest that the semantic information provided by context may facilitate the orthographic learning of irregular words, as measured by orthographic decision task, but not regular words.

Together, the results of the studies reviewed in this section indicate that the semantic information provided by context facilitates the decoding of unfamiliar words but not the retention of their orthographic form. Contextual semantic information only facilitated orthographic learning when they were presented in the form of word-definition and illustration, in a process similar to that of pre-teaching vocabulary to aid reading comprehension. The lack of positive context effects is aligned with Share's (1995) argument that contextual guessing is not a reliable source for word recognition, but leaves the semantic component of the self-teaching hypothesis poorly understood.

Worth mentioning that to date, the majority of self-teaching studies have only examined the effects of contextual semantic information in orthographic learning, but neglected to examine the role of morphology as within-word semantic information. Given that a substantial number of English words are polymorphemic words that contain multiple units of meaning and the growing evidence that as children become more experienced with reading, they begin to rely more on larger orthographic units in the words, it is possible that the semantic information provided by morphemes influences the orthographic learning of polysyllabic-polymorphemic words. Studies examining this possibility are summarized next.

2.3.2.2 Semantic Knowledge Effects in Orthographic Learning: Morphology

Very few studies examined the effects of semantic information provided by morphemes on the orthographic learning of polysyllabic words. A literature search yielded one published peer-reviewed article, Tucker, Castles, Laroche, and Deacon (2016). In this study, the authors assessed whether roots and suffixes facilitated the orthographic learning of morphologically complex pseudowords (i.e., pseudowords with suffix *-er*; e.g., *feaper*) and orthographically complex words (i.e., pseudowords with pseudo-suffix *-le*; e.g., *feaple*). Third and fifth grade children (N = 133) were assigned to one of three study groups: reading pseudo base words (e.g., *feap*), reading morphologically complex pseudowords, or reading orthographically complex words. Children read the target words embedded in short stories accompanied with illustrations. Children's orthographic learning was assessed during the same session in which they completed the orthographic learning (pseudoword reading) task and two–three days later using an orthographic choice task. All children, irrespective of study group, completed the same orthographic choice task which contained sets of four words with a base word subset (e.g., *feap-feep*), a morphologically complex subset (e.g., *feaper-feeper*), and an orthographically complex subset (e.g., *feaple-feeple*). Tucker et al. (2016) carried out a series of univariate analysis of variance (MANOVA) tested to examine the differences in orthographic choice score as function of study group and failed to detect any significant difference in the orthographic learning of words that are orthographically complex and words that are morphologically complex. The authors reported that children's identification of both types of words during the orthographic choice task was above chance level (above 25%). However, there was no significant differences between identifying morphologically related words and orthographically related words. Tucker et al. (2016) concluded that children appear to acquire new whole-word representations of polysyllabic words through an analogy strategy that is not meaning-based. Children's prior exposure to any part of the polysyllabic word, whether it is a morpheme or a meaningless syllable, appears to facilitate its orthographic learning.

The facilitating effects of morphology in the orthographic learning of polysyllabic words was also examined in a pilot study carried by Al Ghanem, Kearns, and Toste

(2015). In this study, 33 fourth and fifth grade children were randomly assigned to one of two context conditions: isolation or context. Children in each condition read a set of 12 disyllabic pseudowords. Half of the words began with a pseudo-prefix (e.g., *fe-dake*) and half of the words began with a real prefix (e.g., *re-dake*). The children in the isolation condition completed a word-nonword categorization task that required them to read individual words, one at a time, then deciding whether they were real words or made up words and placing them in the correct pile. The children in the context condition read the target words embedded in short stories. Children's orthographic learning of target words was assessed three-eight days later using an orthographic choice task that required them to circle the target pseudowords from quadruplet sets (e.g., *redake*: *redake*, *redaik*, *redafe*, *redaif*). The authors analyzed children's performance on the orthographic choice task using mixed-design ANOVA. The results of this study did not reveal a significant main effect of morphology $F(1, 131) = 0.61, p = .43,$ indicating that the semantic information provided by morphemes (prefix *re-* in this study) was not sufficient to facilitate the orthographic learning of polysyllabic words. The lack of morphology effects is consistent with the findings of Tucker et al. (2016), however, while Tucker et al. (2016) had a large sample size ($N = 133$), this pilot study had a small sample size and may have lacked the power to detect significant morphology and context main effects or interactions. One other sample-related differences between the two studies is that all children in Tucker et al. (2016) were typically developing readers and no English language learners were reported. Most children in Al Ghanem et al.'s (2015) pilot study (91%) were identified as children with reading difficulty and 61% of the children were

English language learners. Children with reading difficulty and children who are English language learners tend to have poorer morphological knowledge, compared to their typically developing and native English-speaking peers. It is also possible that the lack of significant morphology effects in Al Ghanem et al.'s (2015) pilot study represents sample idiosyncrasies and cannot be generalized. To put it mildly, the findings concerning the role of morphology in the orthographic learning of polysyllabic words are inconclusive and more studies are needed to determine whether morphemes provide sufficient semantic information that can facilitate the orthographic learning of polysyllabic words.

2.4 Orthographic Learning in Children with Reading Difficulty

Studies examining orthographic learning in children with reading difficulties are scarce and it is still unclear how children with different profiles of reading difficulties perform on orthographic learning and self-teaching tasks. The phonological deficit hypothesis maintains that reading difficulties result from poor phonological decoding skills caused by deficiencies in phonological skills (Vellutino, Fletcher, Snowling, & Scanlon, 2004). This type of reading difficulties is termed 'phonological dyslexia'. Children with phonological dyslexia are presumed to have below average phonological decoding skills, but average sight-word reading. Thus, it is possible that the poor phonological decoding skills of children with phonological dyslexia will impede their ability to decode unfamiliar words and prohibit the formation of word-specific orthographic representations. If this is true, then how these children achieve typical sight-word reading remains unclear. The compensatory processing hypothesis suggests that children with phonological dyslexia may rely on visual processing to store and retrieve whole-word representations and thus may still be able to self-teach unfamiliar words with minimal reliance on phonological decoding (Share & Shalev, 2004).

Another group of children with reading difficulties that is commonly examined is the group of children with ‘surface dyslexia’. Children with surface dyslexia tend to have average phonological processing and phonological decoding skills but below average sight-word reading. These children fail to form functional whole-word representations and continue to rely on phonological decoding to identify words. This group of children has yet to be studied in the self-teaching literature and it is unclear how their profile might impact their orthographic learning through self-teaching mechanism.

Searching the orthographic learning literature for studies that examined orthographic learning in children with reading difficulties yielded two studies, Wang et al. (2014) and Share and Shalev (2004). Wang et al. (2014) trained nine typically developing readers, nine children with phonological dyslexia profile, and nine children with surface dyslexia profile to read target regular and irregular English pseudowords. At the end of the training session, children completed an orthographic choice task and a spelling task that measured their orthographic learning. The results showed that the two groups of children with reading difficulties had poorer phonological decoding skills than the typical children. However, all three groups of children were capable of orthographic learning. Notably, the children with phonological dyslexia profile and the typically developing readers had comparable orthographic learning scores and they both performed better than the children with the surface dyslexia profile. This was true for the results of both the orthographic choice task and the spelling task. The results of this study are aligned with the prediction that children with phonological dyslexia have intact sight-word reading while children with surface dyslexia have impaired sight-word reading. However, the two groups of children can form word-specific orthographic representations.

Share and Shalev (2004) used the standard self-teaching design to examine orthographic learning in Hebrew speaking children with and without reading difficulties—20 children with reading difficulty, 20 chronological age-matched children, and 20 reading age-matched children. The children with reading difficulties and the children in the chronological age-matched group were in fourth through sixth grade and the children in the reading age-matched group were in second grade. The results of this study showed that, when both consonantal and vowel errors were counted, children with reading difficulties had significantly lower rates of target pseudowords decoding accuracy (38.3%) than the other two groups (both above 65%). However, when only consonantal errors were counted, all three groups had decoding accuracy rates above 80%.

Share and Shalev (2004) examined the differences in the orthographic learning in the three groups using an orthographic choice task, a naming task, and a spelling task. The results of the orthographic choice analyses showed evidence for orthographic learning in the reading difficulties group and the chronological age-matched group. However, the children in the chronological age-matched group outperformed the children with reading difficulties (accuracy rates 75% and 61%, respectively). The results of the spelling task analyses mirrored those of the orthographic choice task, but the naming task did not show any evidence of orthographic learning (consistent with the findings of Share, 2004). Surprisingly, the children in the reading age-matched group (second graders) did not show any evidence of orthographic learning in any of the posttest measures. This is a clear contradiction to the findings of Share (1999) who found reliable orthographic learning in second grade children. Overall, the findings of this study indicate that children with reading difficulties learning to read in a highly regular orthography (Hebrew) are capable of self-teaching word specific-representations though to a lesser degree than their typical peers.

To sum up, data on orthographic learning in children with reading difficulties are still limited. However, the current findings indicate that children with reading difficulties are able to self-teach word-specific orthographic representations despite their poor phonological decoding skills. It is possible that these children rely more on a visual processing route to form these orthographic representations, but more studies are needed to fully understand the process of orthographic learning in children with different reading difficulty profiles.

2.5 Conclusion

The current orthographic learning data show that phonological decoding and orthographic skill may be determinant of orthographic learning. However, these data are obtained from studies that focus on the orthographic learning of simple monosyllabic words. It is not clear whether these skills are also related to the orthographic learning of more complex polysyllabic words. The orthographic learning literature has yet to examine the role of morphemes and morphological knowledge (sources of semantic information) in orthographic learning.

Additionally, the current data concerning the role of context in orthographic learning are obtained from studies that varied largely in their conceptualization of contextual semantic information and design, which leaves the role of semantics in the acquisition of whole-word representations insufficiently explained.

Moreover, the orthographic learning literature has limited data concerning understanding individual differences in orthographic learning related to reading skill and linguistic background. Clearly, many gaps exist in the orthographic learning literature and much more studies are needed to fully understand how children independently transition from phonologically decoding words to identifying them through rapid sight-word reading.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Overview

This study examined the orthographic learning of polysyllabic words using an orthographic learning study modeled after Share's (1999) self-teaching paradigm. This study included a polysyllabic words orthographic learning task and two study-specific measures of orthographic learning: an orthographic choice task and a spelling task. It also included measures of child's phonological decoding skill, morphological knowledge, and orthographic knowledge. In this chapter, I provide a brief description of participants' characteristics, study design and procedure, and study materials in this chapter.

3.2 Participants

A total of 73 fourth and fifth grade children (38 males and 35 females; aged 8–11 years) participated in this study. The children attended a suburban elementary school in north eastern the United States. The school served children from predominantly upper-middle class families with a relatively homogenous racial, linguistic, and socioeconomic background composition.

Consistent with the school's demographic composition, of the participants in this study, 97% were Caucasians, 0% received free-reduced-lunch, and 0% English language learners. During the school year in which the data were collected, 94% of the children enrolled in the school were Caucasian, 2% economically disadvantaged, 0.2% English language learners.

The proportion of participants with disability or receiving individualized education program (IEP), as identified by the school, is also consistent with the proportion of this population in the school, 12% in this sample, 15% of the school population. Of children with IEP, two-third (6 children) received services for Specific Learning Disability and one-third (3 children) received services for health problems. None of the participants had developmental or intellectual disability, emotional and behavioral disorder, or was on the autism spectrum. Further participants' demographic information is summarized in Table 1.

Table 1: Demographics

	Whole-Sample (N = 73)		Isolation (n = 35)		Context (n = 38)		Isolation vs. Context		
Variable	n	%	n	%	n	%	χ^2	*df*	*p*
Grade							0.187	1	0.665
4	29	40	13	37	16	42			
5	44	60	22	63	22	58			
IEP							0.878	1	0.349
No	64	88	32	91	32	84			
Yes	9	12	3	9	6	16			
Sex							0.134	1	0.714
Male	38	52	19	54	19	50			
Female	35	48	16	56	19	50			
Race[a]							2.233	2	0.327
Asian	1	**1**	1	3	0	0			
Caucasian	71	**97**	33	94	38	100			
Multi-race	1	**1**	1	3	0	0			

Note. IEP = individualized education program.
[a] Numbers in boldface add up to 99% due to rounding error.

3.3 Procedure

The fourth and fifth grade teachers in the participating school were asked to send consent forms to the parents/guardians of their students. Children who returned signed consent forms indicating approval for participation ($N = 78$) were enrolled in the study. Of those children, one child did not assent to participation and one child withdrew citing severe reading difficulties, and withdrew from the study. The remaining 76 children completed the required two, individually administered, study sessions (approx. 30–35 minutes each). The sessions were completed in a quiet space at the school, during the school day, and at times approved by teachers.

Test administration

All children completed the orthographic learning task at the beginning of the first session and the two orthographic learning measures (spelling and orthographic choice) in the second sessions. Ideally, to reduce priming effects, the two orthographic measures would be administered in separate sessions in a counter balanced order. However, that was not possible due to time constraints and limited number of test administrators. All children completed the spelling task at the beginning of the second session and the orthographic choice task at the end of the session (i.e., approx. 25–30 minutes later). It was determined that the priming effects of seeing the items during the orthographic choice task would have greater priming effects on the spelling task, compared to the reverse order, and the order of administration was kept constant for all children. The two testing sessions were conducted three days apart, except for 8 children (see Table 2 for details). All test sessions were audio recorded using a digital recorder. Of the 76 children, three had incomplete data and were eliminated from the final data set.

Test administrator, scoring, and data entry

All tests were administered and scored by one graduate student with experience working with elementary school children. To ensure accuracy, an undergraduate research assistant double scored the reading tasks using the audio files from the sessions. The test administrator then entered the data to a web-based tool, REDCap (Research Electronic Data Capture, Harris et al., 2009), hosted at Boston University.

Randomization

Multiple levels of randomization were employed in this study to ensure equal distribution across study conditions and stimuli lists. Children were randomly assigned to the two study conditions (isolation vs. context) and to one of the four alternative stimuli lists. First, the de-identified children list was split by grade. Second, using the *=RAND()* function in Microsoft Excel, children in each grade were randomly assigned to one of the study conditions. Last, children in each grade x condition cell were randomly assigned to one of the stimuli lists. Table 2 summarizes the distribution of children across conditions and stimuli lists.

Table 2: Session-Delay and Participant Distribution across Lists

Variable	Whole-Sample (N = 73)		Isolation (n = 35)		Context (n = 38)		Isolation vs. Context		
	n	%	n	%	n	%	χ^2	*df*	*p*
Session-Delay[a]							2.086	3	0.56
3 Days	64	88	31	**89**	33	**87**			
4 Days	7	10	3	**9**	4	**11**			
5 Days	1	1	0	**0**	1	**3**			
6 Days	1	1	1	**3**	0	**0**			
Word List[a]							0.18	3	0.98
List 1	16	22	7	**20**	9	24			
List 2	19	26	9	**26**	10	26			
List 3	20	27	10	**29**	10	26			
List 4	18	25	9	**26**	9	24			

Note. Session-Delay = number of days elapsed between performing the orthographic learning task and completing the measures of orthographic learning.
[a] Numbers in boldface add up to 101% due to rounding error.

Reading skill

Prior to data analysis, children were assigned one of three reading skill groups: typical achievement, reading difficulty, and borderline. The group assignment was determined using children's scores on two subtests of the *Test of Word Reading Efficiency* (TOWRE; Torgesen et al., 1999): Sight Word Efficiency (SWE) and Phonemic Decoding Efficiency (PDE). Children in the typical achievement group were those who had a composite standard score above the 35th percentile. Children in the reading difficulty group were those who had a composite standard score that fell below the 25th percentile. Children in the borderline group were those who had a composite score between the 25th and the 35th percentile. In the whole sample, there were 55 children in the typical achievement group, 6 in the reading difficulty group, and 12 in the borderline group. The reading skill groups were equally distributed across the isolation condition and the context condition: 25 vs. 30 typically achievement, 3 vs. 3 reading difficulty, and 6 vs. 6 borderline, $\chi^2(2) = .113$, $p = .945$.

3.4 Materials

Orthographic Learning Task

The orthographic learning task required children to read a set of target words in one of two context conditions: context or isolation. The target words' specifications and the two task conditions are described below.

Stimuli. The target words were 12 disyllabic pseudowords modeled after two classes of real disyllabic words: 6 dimorphemic and 6 monomorphemic. In real words, dimorphemic words are comprised of a base-word and an affix (e.g., *art-ist*, *re-turn*), and monomorphemic words are comprised of two meaningless syllables (i.e., syllables that do not constitute a base-word or a morpheme and thus do not carry meaning cues; e.g., *tra-vel*). In the target pseudowords, the dimorphemic words contained a pseudo base-word and a real suffix, and the monomorphemic words contained two empty syllables. Given that the base-words used to construct the target dimorphemic words were pseudo base-words and thus, by definition, are empty syllables, they were also used as a first syllable in the monomorphemic words.

All 12 pseudo base-words (1) were four-letter words, (2) followed a CVVC or a CVCC pattern, where *C* denotes a consonant letter and *V* denotes a vowel letter, and (3) formed legal English letter strings. The CVVC and CVCC patterns were selected (as opposed to CVCV, for example) to ensure that adding an affix or a second syllable did not require altering the base-word by omitting a final vowel (e.g., *help* + *-ing* = helping vs. *hope* + *-ing* = *hoping*). An effort was made to balance the base-words based on rime unit's token frequency, which ranged between very low (1) and very high (21775), with a mean of 3640 (*SD* = 6102). Six of the 12 pseudo base-words had a rime unit that had a relatively low-frequency (ranged between 1 and 898) and the other six had a relatively high-frequency (ranged between 1973 and 21775). Token frequencies were obtained from a subset of the Educator's Word Frequency Guide corpus (EWFG; Zeno et al., 1995) that contained 15,093 words and included the frequency counts for grades 1–5. The cut-off point for low- and high-frequency was an arbitrary cut-off point. Worth mentioning, a primary cause of the markedly wide frequency range was the limited options for composing four-letter pseudo words. In many cases, changing one letter to achieve a higher or lower frequency caused the pseudo word to become a real word (e.g., changing the rime unit in *roop* from *-oop* to *-oom* increases the rime frequency from 293 to 4607 but produces the real word *room*). Table 3 lists the pseudo base-words, their spelling pattern, their rimes, and rimes' frequencies.

To create the dimorphemic stimuli, the pseudo base-words were paired with a high- or a low-frequency real suffix (*-ful* or *-ness*, respectively)—the suffix *-ful* had a token frequency of 4819 and the suffix *-ness* had a token frequency of 1269. To create the monomorphemic stimuli, the base words were paired with a high- or a low-frequency empty syllable (*-bel* or *-rass*, respectively)—the syllable *-bel* had a token frequency of 3765 and the syllable *-rass* had a token frequency of 1175. Alternating the pairing of these four units (-*ful*, -*ness*, -*bel*, and -*rass*) and the 12 pseudo base-words produced four parallel word lists (see Appendix A) that were randomly assigned to participants (see Procedure, p. 47). Each list, contained three high-frequency dimorphemic words (those ending with -*ful*), three low-frequency dimorphemic words (those ending with -*ness*), three high-frequency monomorphemic words (those ending with -*bel*), and three low-frequency monomorphemic words (those ending with -*rass*). This pairing procedure ensured counter balancing and controlling for any base-word, suffix, or syllable idiosyncrasies, including the frequency of the base-word rime unit. There was no attempt to control for the stress pattern in the target words.

Table 3: List of Pseudo Base-Words Used to Create Stimuli

Base-Word	Word Pattern	Rime	Rime Frequency
beel	CVVC	-eel	4309
foud	CVVC	-oud	1973
jeal	CVVC	-eal	5222
nawl	CVVC	-awl	278
roop	CVVC	-oop	293
voun	CVVC	-oun	21775
yauk	CVVC	-auk	1
zeet	CVVC	-eet	6257
lerg	CVCC	-erg	898
merd	CVCC	-erd	472
nurk	CVCC	-urk	111
zurt	CVCC	-urt	2088

Orthographic Learning Task, Context Condition. Children enrolled in the context condition read 12 short stories, each of which contained three recurrences of one of the target words. The stories were printed individually (in a landscape orientation) on small U.S. letter size (8.5" x 11) white paper using black 28 pt. Century Gothic font. The test administrator modeled reading aloud using a sample story then instructed the children to read the stories aloud. The stories were presented to the children one at a time, in a random order. No corrective feedback was provided to the children but the test administrator recorded their reading miscues on a scoring sheet.

The target words ending with *-ful* and *-bel* shared the same set of stories (Set 1) and functioned as an adjective. The target words ending with *-ness* and *-rass* shared the same set of stories (Set 2) and functioned as a noun. The following two examples show the contrast between the two sets of stories, respectively. Appendix B contains the full story sets.

Example (1):

(List 1)
My older sister and I made a *yaukful* cake for my mom's birthday party. Everyone at the party liked the cake and said it was very *yaukful*. It was our first time baking and we were happy the cake turned out to be *yaukful*. We told mom we would make it again for her next year.

(List 2)
My older sister and I made a *jealbel* cake for my mom's birthday party. Everyone at the party liked the cake and said it was very *jealbel*. It was our first time baking and we were happy the cake turned out to be *jealbel*. We told mom we would make it again for her next year.

Example (2):

(List 1)
We learned about animals known for their *foudness* in school. One such animal is the lion. Because of their *foudness*, lions sleep 18 to 20 hours a

day. Lions' *foudness* is linked to the warm climates they live in. On a hot day in Africa, lions can sleep up to 24 hours a day.

(List 2)
We learned about animals known for their *lergrass* in school. One such animal is the lion. Because of their *lergrass*, lions sleep 18 to 20 hours a day. Lions' *lergrass* is linked to the warm climates they live in. On a hot day in Africa, lions can sleep up to 24 hours a day.

The stories in Set 1 and Set 2 were matched on multiple linguistic characteristics to ensure that the study results are not modulated by systematic differences between the two sets of stories. The stories' length, word-specific characteristics, easability level, and readability level were assessed using *Coh-Metrix 3.0 Web Too*l (McNamara, Louwerse, Cai, & Graesser, 2005). Each story was one paragraph long. On average, the stories had 4 sentences (*SD* = 0.67; range: 3–5) and 55 words (*SD* = 1.06; range: 54–57). Easability level was assessed using, among other measures, the *Flesch Reading Ease* (FRE) test. The FRE test's scores range between 0 and 100, with higher score indicating easier text (Flesch, 1979). The context stories used in this study had, on average, an easability score of 85 (*SD* = 2.85; range: 79–88), indicating that they are relatively easy to read (Flesch, 1979).

Readability level was assessed using *Flesch-Kincaid Grade Level* scale (FKGL), which showed that, on average, the stories had a readability level suited for grade level 4.4 (*SD* = 4.4; range: 4–5). The FKGL scale converts FRE test scores to a U.S. grade level, with higher FRE scores corresponding to lower grade levels. Note that according to the FKGL formula, an FRE score between 80 and 90 translates to 6 grade level (Flesch, 1979), which suggests that the estimation of the FKGL grade level for the stories may be imprecise, possibly due to the limitations in the length of the stories. In general, the FKGL scale requires that the text to contain a minimum of 200 words for accurate grade level conversion (Graesser et al., 2014) and the stories used in this study had a maximum length of 57 words. Still, the obtained grade readability levels were consistent with the information provided by the word characteristics and easability level indicators calculated by Coh-Metrix. Table 3 summarizes story characteristics provided by a set of selected Coh-Metrix measures for all stories and across the two sets of stories, Set 1 and Set 2. As evident in Table 4, the stories in Set 1 and Set 2 were closely matched on all indicators.

Orthographic Learning Task, Isolation Condition. Children enrolled in the isolation condition completed a card-sort (categorization) task modeled after the orthographic learning task used in Nation et al. (2007). The task required the children to read a set of 108 words and separate them into a “real word” pile and a “made-up word” pile. The word set contained 36 pseudoword-cards (12 target pseudowords x 3) and 72 real words. The words were printed individually in the center of 3" x 5" blank index cards (landscape orientation) using black 28 pt. Century Gothic font. A small U.S. letter size (8.5" x 11") white paper with two rectangles labeled “real words” and “made-up words” was used as a sorting mat. The test administrator placed a sample card set, face down, and the sorting mat on the table and modeled drawing one card at a time, reading the word on it aloud, deciding whether it was a real word or a made-up word, and placing it on the sorting mat. When the modeling was completed, the test administrator placed the shuffled set of 108 cards, face down, on the table and instructed the children to begin

Table 4: Summary of Readability Indicators for Context Condition Stories

	All Stories				Set 1				Set 2				Set 1 vs. Set 2		
Indicator	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*t*	*df*	*p*
Descriptives															
SSC	4	0.67	3	5	5	0.55	4	5	4	0.82	3	5	0.415	10	0.687
WC	55	1.06	54	57	56	1.22	54	57	55	0.89	54	56	0.808	10	0.438
SSL[a]	12	1.60	9	14	13	1.29	11	14	12	1.85	9	14	0.994	10	0.344
WLsy[a]	1	0.05	1	1	1	0.05	1	1	1	0.06	1	1	-0.597	10	0.564
WLlt[a]	4	0.22	4	4	4	0.17	4	4	4	0.26	4	4	-1.203	10	0.257
Word Information															
FRQa[a]	3	0.10	3	3	3	0.08	3	3	3	0.13	3	3	0.027	10	0.979
AOAc[a]	245	47.8	183	358	230	19.0	202	251	259	64.5	183	358	-1.045	10	0.321
IMGc[a]	445	40.1	371	499	440	39.4	371	488	451	43.6	401	499	-0.487	10	0.637
Text Easability															
NAR[b]	92	11.5	66	100	93	11.0	73	100	92	12.9	66	98	0.102	10	0.921
SYN[b]	39	27.2	6	80	30	15.8	10	54	48	34.2	6	80	-1.214	10	0.253
CNC[b]	83	26.4	9	100	79	36.3	9	99	88	12.9	72	100	-0.573	10	0.58
REFC[b]	92	10.9	68	100	95	8.85	77	100	90	13.0	68	100	0.827	10	0.428
DPC[b]	64	27.8	20	100	55	32.5	20	100	74	20.5	50	100	-1.214	10	0.253
Readability															
FRE	85	2.85	79	88	85	2.54	82	88	84	3.35	79	88	0.328	10	0.749
FKGL	4.4	0.15	4	5	4.5	0.09	4	5	4.4	0.18	4	5	1.882	10	0.089

Note. SSC = Sentence count; WC = Word count; SSL = Sentence length, number of words; WLsy = Word length, number of syllables; WLlt = Word length, number of letters; FRQa = CELEX Log frequency for all words; AOAc = Age of acquisition for content words; IMGc = Imageability for content words; NAR = Narrativity; SYN = Syntactic simplicity; CNC = Word concreteness; REFC = Referential cohesion; DPC = Deep cohesion; FRE = Flesch reading ease; FKGL = Flesch-Kincaid grade level.

[a] Average score

[b] Percentile

drawing the cards. The test administrator did not provide corrective feedback for reading or sorting but recorded their reading miscues and sorting errors on a scoring sheet.

The set of real words used in this task was comprised of 72 words randomly selected from the set of unique real words appeared in the stories used in the context condition ($N = 260$). Welch's t-test for unequal variances was used to examine the differences in average token frequency between the set of unique real words used in the stories and the subset used in this task. The test results did not reveal a significant difference in token frequency between the two sets of words, indicating that children in the context condition and children in the isolation condition encountered distractors of similar frequency, $t(73) = 1.360$, $p = 0.178$. The real words used in this task are listed in Appendix C.

Children's reading of the target pseudowords was audio recorded and scored for accuracy. The accuracy of the pronunciation of the target pseudowords was judged based on (1) its plausibility based on the letter-sound conventions in the English language, and (2) whether it matched one of the pronunciations produced by a group of adult readers. Overall, children read the target pseudowords with 73% accuracy. Children enrolled in the isolation condition had a higher average reading accuracy rate than children enrolled in the context condition, 76% and 70%, respectively ($t = 1.55$, $df = 71$, $p = .063$). For individual lists, children had an average reading accuracy of 75% for List 1, 73% for List 2, 69% for List 3, and 76% for List 4. Table 5 summarizes the decoding accuracy rates by item and Table 6 summarizes the decoding accuracy rates by item and condition.

Table 5: Target Pseudowords Reading Accuracy by Item

List 1 (n = 16)		List 2 (n = 19)		List 3 (n= 20)		List 4 (n = 18)	
Stimulus	%	Stimulus	%	Stimulus	%	Stimulus	%
beelrass	75	beelful	63	beelness	65	beelbel	83
foudness	44	foudbel	47	foudrass	40	foudful	50
jealness	93	jealbel	68	jealrass	55	jealful	83
lergbel	56	lergrass	58	lergful	55	lergness	56
merdbel	69	merdrass	74	merdful	95	merdness	89
nawlrass	69	nawlful	100	nawlness	65	nawlbel	78
nurkrass	75	nurkful	100	nurkness	85	nurkbel	94
roopness	100	roopbel	79	rooprass	70	roopful	89
vounful	94	vounness	79	vounbel	65	vounrass	61
yaukful	44	yaukness	68	yaukbel	45	yaukrass	33
zeetful	88	zeetness	58	zeetbel	90	zeetrass	100
zurtbel	94	zurtrass	79	zurtful	100	zurtness	94

Table 6: Target Pseudowords Reading Accuracy by Item and Condition

List 1			List 2			List 3			List 4		
Stimulus	IC % (n = 7)	CC % (n = 9)	Stimulus	IC % (n = 9)	CC % (n = 10)	Stimulus	IC % (n = 10)	CC % (n = 10)	Stimulus	IC % (n = 9)	CC % (n = 9)
beelrass	57	89	beelful	78	50	beelness	80	50	beelbel	89	78
foudness	43	44	foudbel	56	40	foudrass[b]	60	20	foudful	67	33
jealness	86	100	jealbel	78	60	jealrass	70	40	jealful	89	78
lergbel	43	67	lergrass	67	50	lergful	60	50	lergness	67	44
merdbel	71	67	merdrass	67	80	merdful	100	90	merdness	89	89
nawlrass	86	56	nawlful	100	100	nawlness	80	50	nawlbel	89	67
nurkrass	71	78	nurkful	100	100	nurkness	80	90	nurkbel	100	89
roopness	100	100	roopbel	89	70	rooprass	80	60	roopful	78	100
vounful	86	100	vounness	89	70	vounbel	70	60	vounrass	78	44
yaukful[a]	14	67	yaukness	67	70	yaukbel	50	40	yaukrass	33	33
zeetful	86	89	zeetness	56	60	zeetbel	90	90	zeetrass	100	100
zurtbel	100	89	zurtrass	78	80	zurtful	100	100	zurtness	89	100

Note. IC % = percent of decoding accuracy in the isolation condition; CC = percent of decoding accuracy in the context condition.

[a] Difference in accuracy rates across conditions is significant (t = -2.39, df = 16, p = .030)

[b] Difference in accuracy rates across conditions is marginally significant (t = -1.9, df = 18, p = .074)

Measures of Orthographic Learning

Children's orthographic learning was assessed using two study-specific orthographic learning measures: orthographic choice and spelling.

Orthographic Choice Task. The orthographic choice task required the children to circle the target words from sets of four words: the target pseudoword, a homophone file, a distractor, and a distractor homophone (e.g., target *foudbel*, set includes *foudbel* - *fowdbel* - *toudbel* - *towdbel*). As shown in Appendix D, the order of the words in each of the 12 orthographic choice sets, and the order of the sets were randomized. In the test protocol, the sets were presented in three pages (three sets per page).

The base-words of the target pseudowords and their homophones were balanced on rime frequency to ensure that the children's accurate selection of targets over homophones is not the result of the targets having higher frequency. Of the 12 orthographic choice sets, 6 sets had targets with base-words that had rime token frequencies higher than those of the homophones, and 6 sets had homophones with base-words that had rime token frequencies higher than those of the targets. Frequencies for the rime of the base-words used to create the targets, the homophones, and the visual distractors and their homophones are listed in Table 7.

Table 7: List of Pseudo Base-Words Used to Create Orthographic Choice Task

Target			Homophone Foil				
Base-Word	Rime	Rime Freq.	Base-Word	Rime	Rime Freq.	VSD	DH
nurk	-urk	111	nerk	-erk	**169**	nurl	nerl
yauk	-auk	1	yawk	-awk	**175**	vawk	vauk
nawl	-awl	278	naul	-aul	**679**	nawt	naut
zurt	-urt	2088	zert	-ert	**2425**	surt	sert
beel	-eel	4309	beal	-eal	**5222**	leal	leel
zeet	-eet	6257	zeat	-eat	**13194**	zeed	zead
roop	-oop	**293**	rewp	-ewp	4	noop	newp
merd	-erd	**472**	murd	-urd	444	merp	murp
lerg	-erg	**898**	lurg	-urg	155	ferg	furg
foud	-oud	**1973**	fowd	-owd	747	toud	towd
jeal	-eal	**5222**	jeel	-eel	4309	yeal	yeel
voun	-oun	**21775**	vown	-own	17799	voum	vowm

Note. Rhyme Freq. = rime frequency; VSD = visually similar distractor;
DH = distractor's homophone.
[a] Frequency counts in boldface indicate higher token Frequency for the target-homophone foil pair.

Spelling. The spelling task required the children to reproduce the target words. The tester read the target words, one at a time, and the children wrote them. The tester read each word three time enunciating each syllable in the word. The spelling items were scored as 0 for incorrect spellings and as 1 for correct spellings. The spelling was given a correct spelling code only when it matched the spelling of the target pseudoword. Homophonic spellings were given incorrect spelling code, 0.

The orthographic choice score and the spelling score had a significant medium correlation (r = .42; p = 0.000) and were combined to create a composite orthographic learning score.

General Skill Measures

A number of standardized and researcher designed measures were used to assess children's phonological decoding skill, morphological knowledge, and orthographic knowledge. Those tests are described below, their descriptive statistics across conditions are summarized in Table 8 and their correlations with the orthographic learning measures are listed in Table 9.

Table 8: Descriptive Statistics by Conditions

	Isolation (n = 35)				Context (n = 38)				Isolation vs. Context		
Variable	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max	*t*	*df* [a]	*p*
WRMT3-WA	19.5	3.41	11	24	18.9	4.00	11	25	0.684	72.5	.496
OCT	59.9	2.87	53	65	58.2	4.93	43	64	1.731	61.6	.089
LST	27.1	1.50	24	30	27.1	1.65	23	30	0.173	73.0	.863
TMS-D	17.9	4.02	10	25	17.2	4.03	7	24	0.686	72.5	.495
AKT	41.2	9.20	23	57	43.7	7.93	26	61	-1.258	69.3	.213

Note. WRMT3-WA = Woodcock Reading Mastery Test, Third Edition-Word Attack Subtest (Woodcock, 2011; OCT = Orthographic Choice Test (Olson et al., 1985); LST = Letter String Test (Cassar & Treiman, 1997); TMS-D = Test of Morphological Structure-Derivation (Carlisle, 2000); AK = Affix Knowledge Test (Mitchell & Brady, 2014).
[a] Welch's degrees of freedom.

Phonological Decoding Skill. Children's phonological decoding skill was measured using the *Woodcock Reading Mastery Test, third Edition-Word Attack* subtest (WRMT3-WA; Woodcock, 2011). The WRMT3-WA is an untimed test that requires children to read a set of increasingly difficult pseudowords. After reading two practice pseudowords, the children start reading the set at the item corresponding with their grade level. The test has a basal of three nonconsecutive correct items and a ceiling of four consecutive incorrect items. The test has 26 items and split-half reliability that ranges between .68 and .98.

In this sample, the WRMT3-WA score had a significant medium correlation with the composite orthographic learning score (r = .30, p = .011), and with the spelling score (r = .36, p = .002), but only a small, non-significant, correlation with the orthographic choice score (r = .14, p = .223). These correlations are consistent with a larger role of phonological decoding during spelling. They are, however, noticeably smaller than the correlations reported in earlier orthographic learning studies examining orthographic learning in English monosyllabic words. The WRMT3-WA score had a significant large, correlation with the composite orthographic learning score in Cunningham (2006; r = .53, p < .05) and with the spelling score in Cunningham et al. (2002; r = .53, p < .05), and a medium correlation with the orthographic choice score in Cunningham (2006; r = .33, p < .05) and in Cunningham (2002; r = .32, p < .05).

Morphological Knowledge. Children's morphological knowledge was measured using the *Test of Morphological Structure-Part 1: Derivation* (TMS-D; Carlisle, 2000), and the *Affix Knowledge Test* (AKT; Mitchell & Brady, 2014). The TMS-D required the children to use a visually presented root word to complete a visually presented sentence (e.g., *humor. The story was quite* ______________.; Carlisle, 2000). The test administrator read the root word and the sentence and the children read along then provided a verbal response. The test administrator recorded the children's responses on a scoring sheet (0 = incorrect answer, 1 = correct answer). The test contains 28 items (see Appendix E) and has an internal consistency of .89.

The AKT is comprised of four parts: Suffixed real words, prefixed real words, suffixed pseudowords, prefixed pseudowords. The test required the children to circle the correct meaning of a given affixed word from a set of three answers (e.g., real word: *Do you think the word 'warmish' means: a) Very warm b) A little cold c) Kind of warm*; Pseudoword: *A. 'Mox' is a made-up word that means 'smooth.'*, *A1. Which of these made-up words could mean 'possible to smooth out? a) moxist b) moxable c) moxful*). All stimuli were presented in a printed form. The test administrator read the target words and the answer options and the children read along. The children then provided their answer verbally and the test administrator recorded the children's responses on a scoring sheet (0 = incorrect answer, 1 = correct answer). The test contains a total of 64 items (see Appendix F) and has an internal consistency of .87.

The total TMS-D score and the total AKT score were standardized and used to create a composite morphological knowledge score. In this sample, the two scores had a significant large correlation (r = .63, p = .000). This large correlation is consistent with the large correlation between the two tasks reported in Mitchell and Brady (2014; r = .70, p = .01). No prior studies have reported on the correlations between the orthographic learning measures used in this study and the TMS-D score or the AKT score. However, the large correlation found in this study is consistent with possible role of morphology in the orthographic learning of polysyllabic-polymorphemic words.

Orthographic Knowledge. Children's orthographic knowledge was measured using an abbreviated version of Olson et al.'s (1985) *Orthographic Choice Test* (OCT) and a modified version of Cassar and Treiman's (1997) *Letter String Task* (LST), created by Cunningham et al. (2002). The OCT required the children to circle the correct word (spelling) from a pair of real word and pseudo-homophone (e.g., *mystery-mysterey*). The test contains 65 pairs (see Appendix J), compared to the 80 pairs in Olson et al. (1985). This version of the test was adapted by Kearns (2015), after observing lack of variability in 15 of the original 80 pairs, and has an internal consistency of .94 (Kearns, 2015).

The LST required the children to circle the word that most resemble a real word from a pair of pseudowords (e.g., *ffim-phim*) and measured children's knowledge of permissible orthographic units in English. The test contains 30 words (see Appendix K).

In this sample, the total OCT score had a significant medium correlation with the composite orthographic learning score (r = .44, p = .000), orthographic choice score (r = .43, p = .000), and spelling score (r = .30, p = .008). The correlation with the composite orthographic learning score is smaller than that previously reported by Cunningham (2006; r = .60, p < .05). The correlation with the orthographic choice score is smaller than that previously reported by Cunningham (2006; r = .51, p < .05) but larger than that reported by Cunningham et al. (2002; r = .34, p < .05). The correlation with spelling score is larger than that previously reported by Cunningham et al. (2002; r = .11, p > .05) but smaller than that reported by Cunningham (2006; r = .51, p < .05). Nevertheless, these correlations are consistent with the possible role of orthographic knowledge in the acquisition of whole-word representations.

In this sample, the total LST score had a significant medium correlation with the composite orthographic learning score (r = .31, p = .007) and with the spelling score (r = .33, p = .004), but only a small, non-significant, correlation with the orthographic choice score, orthographic choice score (r = .19, p = .101). The correlation with the composite orthographic learning score is smaller than that previously reported by

Cunningham (2006; $r = .56$, $p < .05$). The correlation with the orthographic choice score is smaller than that previously reported by Cunningham (2006; $r = .46$, $p < .05$). The correlation with spelling score is larger than that previously reported by Cunningham et al. (2006; $r = .19$, $p < .05$). Nonetheless, these correlations are consistent with the possible role of sub-lexical orthographic knowledge in the acquisition of whole-word representations.

The total OCT score and the total LST score were standardized and used to create a composite orthographic knowledge score. In this sample, the two scores had a significant medium correlation ($r = .33$, $p = .006$). This correlation is markedly smaller than the one previously reported by Cunningham (2006; $r = .63$, $p < .05$) and may represent sample idiosyncrasies.

Table 9: Descriptive Statistics and Correlations for Variables in Regression Analysis

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
Orthographic learning measures													
1. Orthographic learning composite	1												
2. Orthographic choice posttest	.84***	1											
3. Spelling posttest	.84***	.42***	1										
Phonological decoding measure													
4. WRMT3-WA	.30**	.14	.36**	1									
Morphological knowledge measures													
5. Morphological knowledge composite	.47***	.42***	.38***	.25*	1								
6. TMS-D	.41***	.37***	.33**	.12	.90***	1							
7. AKT	.43***	.38***	.36**	.34**	.90***	.63***	1						
Orthographic knowledge measures													
8. Orthographic knowledge composite	.46***	.39***	.39***	.43***	.50***	.46***	.45***	1					
9. OCT	.44***	.43***	.31**	.34**	.49***	.45***	.44***	.81***	1				
10. LST	.31**	.19†	.33**	.36**	.33**	.30**	.30**	.81***	.33**	1			
Reading skill measures													
11. Reading skill composite SS	.04	-.10	.16	.54***	.25*	.22†	.23*	.38***	.33**	.29**	1		
12. TOWRE-SWE SS	.00	-.07	-.07	.33**	.27**	.25*	.24*	.38***	.33**	.29**	.93***	1	
13. TOWRE-PDE SS	.07	-.10	.23*	.70***	.18	.15	.17	.30**	.26**	.23*	.90***	.67***	1
M	0.00	0.60	0.21	19.2	0.00	17.5	42.5	0.00	59.0	27.1	203	101	102
SD	-0.84	-0.18	-0.13	-3.71	-0.90	-4.01	-8.6	-0.81	-4.13	-1.57	-20.8	-12.5	-10.3

Note. WRMT3-WA = Woodcock Reading Mastery Test, Third Edition-Word Attack subtest (Woodcock, 2011); TMS-D = Test of Morphological Structure-Derivation (Carlisle, 2000); AKT = Affix Knowledge Test (Mitchell and Brady, 2014); OCT = Orthographic Choice Test (Olson et al., 1985); LST = Letter String Test (Cassar & Treiman, 1997); TOWRE-SWE SS = Test of Word Reading Efficiency-Sight Word Efficiency subtest standard score (Torgesen et al., 1999); TOWRE-PDE = Test of Word Reading Efficiency-Phonemic Decoding Efficiency subtest standard score (Torgesen et al., 1999).
* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

CHAPTER FOUR: DATA ANALYSIS AND RESULTS

4.1 Overview

The purpose of this study was to examine effects of the semantic information provided by morphemes and context on the orthographic learning of polysyllabic words as well as the unique contribution of morphological knowledge in the orthographic learning of polysyllabic words. In this chapter, I first discuss children's performance on the orthographic learning measures; the orthographic choice task and the spelling task. I then describe the statistical methods I used to analyze the data and summarize the results the analyses yielded.

4.2 Performance on Orthographic Choice Task and Spelling Task

Children's acquisition of functional whole-word representations of the target polysyllabic-pseudowords was measured using two orthographic learning measures: an orthographic choice task and a spelling task. Children's scores on the orthographic choice task showed orthographic learning above chance level, 25% (z = 24.1, p = .000). On average, across lists and conditions, children selected the target pseudoword 60% of the time. For individual lists, children selected the target pseudoword 57% of the time for List 1, 55% for List 2, 63% for List 3, and 65% for List 4. Table 10 summarizes the orthographic choice accuracy rates by item.

Table 10: Performance on Orthographic Choice Task by Item

List 1 (n = 16)		List 2 (n = 19)		List 3 (n = 20)		List 4 (n = 18)	
Stimulus	%	Stimulus	%	Stimulus	%	Stimulus	%
yaukful	56	yaukness	42	yaukbel	75	yaukrass	78
jealness	56	jealbel	68	jealrass[a]	35	jealful	44
zurtbel	44	zurtrass[a]	32	zurtful[a]	40	zurtness	44
beelrass	50	beelful	74	beelness	60	beelbel	89
vounful	63	vounness	42	vounbel	60	vounrass	89
roopness	94	roopbel	68	rooprass	80	roopful	78
merdbel	44	merdrass[a]	37	merdful	70	merdness	56
nurkrass	56	nurkful	74	nurkness	70	nurkbel	44
zeetful	69	zeetness	58	zeetbel	80	zeetrass	61
foudness	69	foudbel	58	foudrass	75	foudful	61
lergbel[a]	31	lergrass	42	lergful	55	lergness	56
nawlrass	56	nawlful	68	nawlness	55	nawlbel	83

[a] Proportion test showed a non-significant above chance (> 25%) accuracy rate.

Children's scores on the spelling task failed to show orthographic learning above chance level, 50% (z = -17.1, p = 1.000). On average, across lists and conditions, children spelled the target pseudowords with 21% accuracy. For individual lists, children spelled the target pseudowords correctly 57% of the time for List 1, 23% for List 2, 21% for List 3, and 20% for List 4. Nevertheless, planned analyses were carried out to detect any patterns in the orthographic learning of polysyllabic words, as measured by the spelling task. Table 11 summarizes the spelling accuracy rates by item.

Table 11: Performance on Spelling Task Item

List 1 (n = 16)		List 2 (n = 19)		List 3 (n = 20)		List 4 (n = 18)	
Stimulus	%	Stimulus	%	Stimulus	%	Stimulus	%
yaukful	6	yaukness	21	yaukbel	10	yaukrass	0
jealness	25	jealbel	0	jealrass	10	jealful	22
zurtbel	19	zurtrass	21	zurtful	35	zurtness	44
beelrass	13	beelful	37	beelness	50	beelbel	11
vounful	44	vounness	0	vounbel	15	vounrass	0
roopness	19	roopbel	5	rooprass	20	roopful	17
merdbel	19	merdrass	26	merdful	10	merdness	39
nurkrass	25	nurkful	42	nurkness	30	nurkbel	6
zeetful	50	zeetness	37	zeetbel	15	zeetrass	33
foudness	50	foudbel	26	foudrass	45	foudful	39
lergbel	0	lergrass	32	lergful	5	lergness	33
nawlrass	6	nawlful	5	nawlness	0	nawlbel	0

Note. Proportion test showed a non-significant above chance (> 50%) accuracy rate for all items.

4.3 Morphology and Context Effects Analyses

A mixed-design ANOVA with two levels of word-type (monomorphemic, polymorphemic) as a within-subjects factor; and two levels of condition (isolation, context) and three levels of reading skill (typical achievement, borderline, reading difficulty) as between-subjects factors was used to examine the facilitating effects of morphology and context in the orthographic learning of polysyllabic, as measured by the composite orthographic learning score. In order to detect variations in the quality of the acquired whole-word representations, two additional identical analyses were carried out for the component orthographic learning measures (the orthographic choice task and the spelling task). The results of the three analyses are summarized in this section.

4.3.1 Composite Orthographic Learning Score Analysis

The results of the ANOVA concerning the composite orthographic learning score is presented in Table 12. The analysis yielded a significant main effect for word-type $F(1, 280) = 4.74, p = .030, \eta_p^2 = 0.017$, with children having higher composite orthographic learning scores for polysyllabic-polymorphemic words than for polysyllabic-monomorphemic words, $M = .12, SD = .82$ and $M = -0.12, SD = .72$, respectively. The analysis also yielded a significant main effect for condition, $F(1, 280) = 11.0, p = .001, \eta_p^2 = 0.038$, with children enrolled in the isolation condition having higher composite orthographic learning scores than for those enrolled in the context condition , $M = .12, SD = .80$ and $M = -0.11, SD = .74$, respectively. Additionally, the analysis yielded a marginally significant interaction between condition and reading skill, $F(2, 280) = 2.57, p = .079, \eta_p^2 = 0.018$, indicating that the context effect varied by children's reading skill. None of the other main effects or interactions was statistically significant, $F \leq 0.57, p \geq .569, \eta_p^2 \leq 0.004$.

Table 12: ANOVA for Composite Orthographic Learning Score

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	2.776	1	2.776	4.74	0.030	0.017
Condition	6.412	1	6.412	11.0	0.001	0.038
RD Skill	0.069	2	0.034	0.06	0.943	0.000
Condition x Word-type	0.003	1	0.003	0.00	0.946	0.000
Condition x Reading Skill	3.005	2	1.503	2.57	0.079	0.018
Word-type x Reading Skill	0.451	2	0.225	0.39	0.681	0.003
Condition x Word-type x Reading Skill	0.662	2	0.331	0.57	0.569	0.004
Error	164	280	0.585			
Total	176	291	0.605			

The interaction between condition and reading skill was examined through a set of post-estimation contrasts. The contrasts showed that the composite orthographic learning scores for children in the typically achieving group did not vary by context condition, $F(1, 218) = 1.06$, $p = .305$, $d = .14$. The contrasts, however, showed a significant medium context effect on the composite orthographic learning scores for children in the borderline group, $F(1, 46) = 5.32$, $p = .026$, $d = 0.67$, and a significant large context effect on the composite orthographic learning scores for children in the reading difficulty group, $F(1, 22) = 6.32$, $p = .020$, $d = 1.03$. Both, children in the borderline group and children in the reading difficulty group enrolled in the isolation condition had higher composite orthographic learning than those enrolled in the context condition. Table 13 presents the composite orthographic learning scores by context condition and reading skill groups and Figure 3 illustrates the interaction between context condition and reading skill.

Table 13: Composite Orthographic Learning Scores as a Function of Reading Skill and Condition

	Condition		
Reading Skill	Isolation	Context	Overall
Typical Achievement			
Mean	0.05	-0.06	-0.01
SD	(0.81)	(0.76)	(0.78)
Borderline			
Mean	0.28	-0.21	0.03
SD	(0.77)	(0.68)	(0.76)
Reading Difficulty			
Mean	0.38	-0.34	0.02
SD	(0.73)	(0.67)	(0.78)
Overall			
Mean	0.12	-0.11	0.00
SD	(0.80)	(0.74)	(0.78)

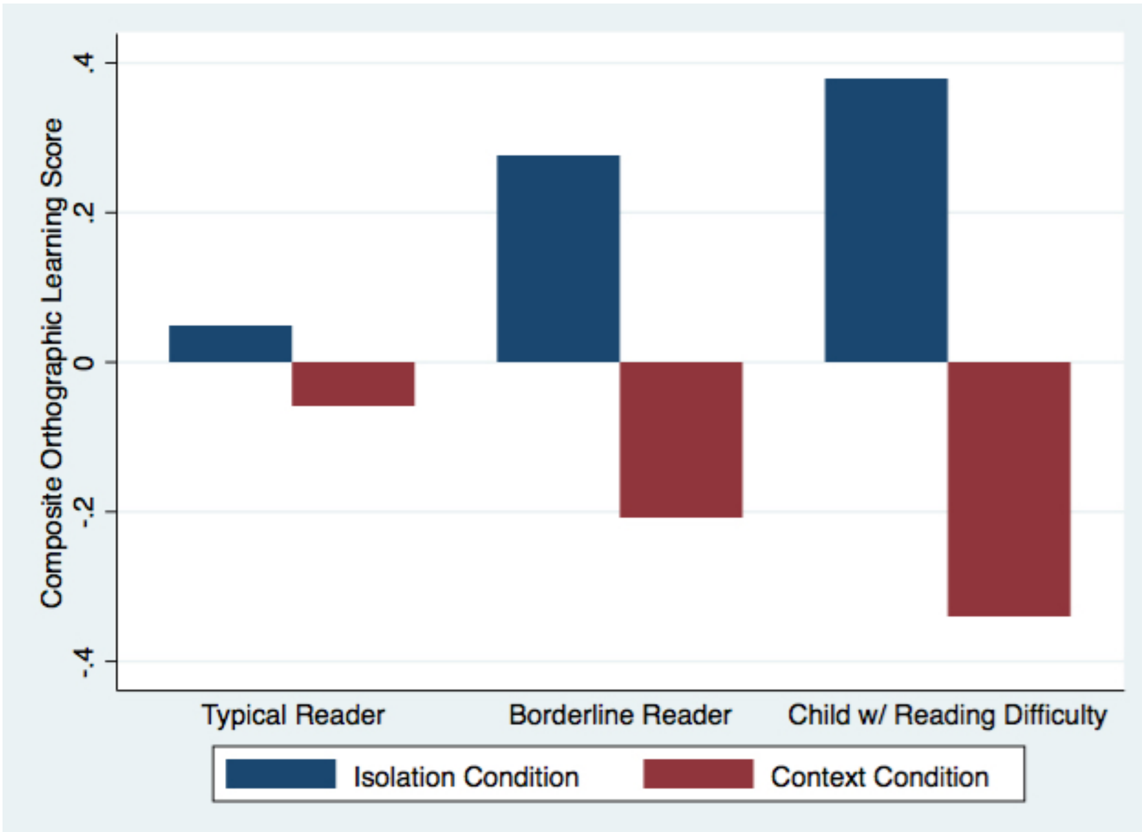

Figure 3: Composite orthographic learning scores by reading skill and context condition.

Overall, the results of this analysis indicate that the semantic information provided by morphology facilitates the orthographic learning of polysyllabic in children with and without reading difficulty. The results also indicate that the semantic information provided by context interferes with the orthographic learning of polysyllabic words, especially for struggling readers and children with reading difficulty.

4.3.2 Orthographic Choice Score Analysis

The results of the ANOVA concerning the orthographic choice task is presented in Table 14. The analysis yielded a significant main effect for condition, $F(1, 280) = 5.86$,

p = .016, $\eta_p^2 = 0.020$, with children enrolled in the isolation condition having higher orthographic choice scores than for those enrolled in the context condition, M = .63, SD = .29 and M = .58, SD = .31, respectively. The analysis also yielded a marginally significant interaction between condition and reading skill, $F(2, 280) = 2.86$, p = .059, $\eta_p^2 = 0.020$, indicating that the context effect varied by children's reading skill. None of the other main effects or interactions was statistically significant, $F \leq 2.03$, $p \geq .155$, $\eta_p^2 \leq 0.010$.

Table 14: ANOVA for Orthographic Choice Score

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	0.000	1	0.000	0.00	0.971	0.000
Condition	0.527	1	0.527	5.86	0.016	0.020
RD Status	0.133	2	0.066	0.74	0.480	0.005
Condition x Word-type	0.183	1	0.183	2.03	0.155	0.007
Condition x Reading Skill	0.514	2	0.257	2.86	0.059	0.020
Word-type x Reading Skill	0.080	2	0.040	0.45	0.641	0.003
Condition x Word-type x Reading Skill	0.248	2	0.124	1.38	0.254	0.010
Error	25.19	280	0.090			
Total	26.36	291	0.091			

The interaction between reading skill and condition was examined through a set of post-estimation contrasts that showed that the context condition had no effect on the orthographic choice score for children in the typically achieving group, $F(1, 286) = 0.00$, p = .980, d = .003. The contrasts also showed a significant large context effect on the orthographic choice score of children in the borderline group, $F(1, 286) = 5.83$, p = .016, $d = 0.694$, and a medium, though not significant, context effect on the orthographic choice score for children in the reading difficulty group, $F(1, 286) = 1.87$, p = .173, *d* = 0.545. children in the borderline group and children in the reading difficulty group enrolled in the isolation condition had higher orthographic choice score than those enrolled in the context condition. Table 15 presents the orthographic choices scores across reading skill groups and context conditions and Figure 4 illustrates the interaction between context condition and reading skill.

Table 15: Performance on Orthographic Choice Task by Reading Skill and Condition

	Condition		
Reading Skill	Isolation	Context	Overall
Typical Achievement			
Mean	0.59	0.59	0.59
SD	(0.30)	(0.30)	(0.30)
Borderline			
Mean	0.72	0.51	0.62
SD	(0.23)	(0.35)	(0.32)
Reading Difficulty			
Mean	0.75	0.58	0.67
SD	(0.29)	(0.32)	(0.31)
Overall			
Mean	0.63	0.58	0.60
SD	(0.29)	(0.31)	(0.30)

Overall, the results of this analysis indicate that the semantic information provided by context interferes with the orthographic learning of polysyllabic words, especially for struggling readers and children with reading difficulty. The results also indication that the semantic information provided by morphology neither facilitates or interferes with the orthographic learning of polysyllabic words in children with and without reading difficulty.

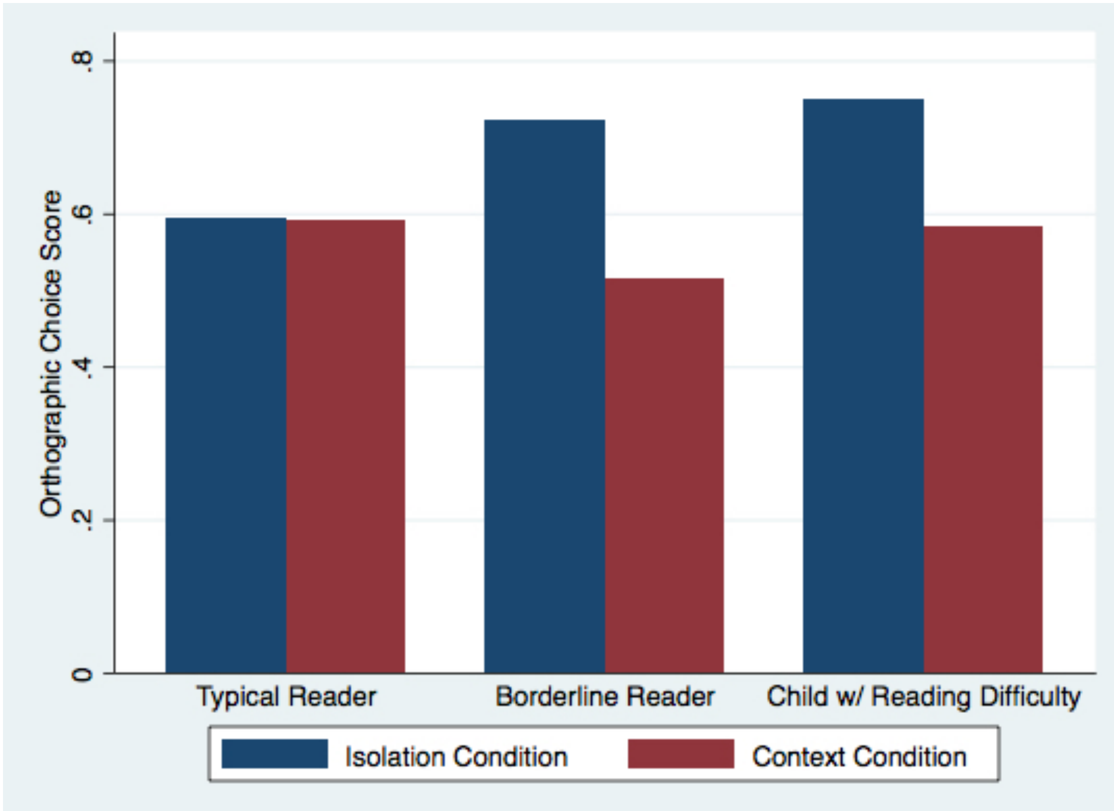

Figure 4: Orthographic choice scores by reading skill and context condition.

4.3.3 Spelling Score Analysis

The results of the ANOVA concerning the spelling task is presented in Table 16. The spelling analysis yielded a significant main effect for word-type, $F(1, 280) = 11.6$, $p = .001$, $\eta_p^2 = 0.040$, with children polysyllabic-polymorphemic words more accurately than polysyllabic-monomorphemic words, $M = .27$, $SD = .27$ and $M = .15$, $SD = .21$, respectively. The analysis also yielded a significant main effect for condition, $F(1, 280) = 7.53$, $p = .007$, $\eta_p^2 = 0.026$, with children enrolled in the isolation condition spelling more words accurately than those enrolled in the context condition, $M = .25$, $SD = .28$ and $M = .18$, $SD = .22$, respectively. None of the other main effects or interactions was significant, $F \leq 2.49$, $p \geq .116$, $\eta_p^2 \leq 0.009$.

Table 16: ANOVA for Spelling Score

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	0.688	1	0.688	11.6	0.001	0.040
Condition	0.445	1	0.445	7.53	0.007	0.026
Reading Skill	0.055	2	0.027	0.46	0.631	0.009
Condition x Word-type	0.147	1	0.147	2.49	0.116	0.003
Condition x Reading Skill	0.153	2	0.077	1.29	0.276	0.009
Word-type x Reading Skill	0.031	2	0.016	0.26	0.769	0.002
Condition x Word-type x Reading Skill	0.123	2	0.061	1.04	0.355	0.007
Error	16.57	280	0.059			
Total	18.42	291	0.063			

Overall, the results of this analysis indicate that the semantic information provided by morphology facilitates the orthographic learning of polysyllabic words. The results also indicate that the semantic information provided by context interferes with the orthographic learning of polysyllabic words. The facilitating effect of morphology and the inhibiting effect of context appeared to be true for children with and without reading difficulty.

To summarize, three sets of analyses examined the effects of morphology and context in the orthographic learning of polysyllabic words as measured by the composite orthographic learning score, orthographic choice score, and spelling score. Overall, the results of these analyses showed that children, irrespective of their reading skill, acquired higher quality representations of polysyllabic-polymorphemic words than of polysyllabic-monomorphemic words. The results also showed that children acquired higher quality representations of polysyllabic words when they were presented in isolation than when they were presented in context. The negative context effect appeared to be moderated by children's reading skill—typically developing children appeared to acquire high-quality representations of polysyllabic words, irrespective of the context condition in which the words were presented. Children in the borderline group and children in the reading difficulty group, however, appeared to acquire higher quality representations of polysyllabic words when they were presented in isolation than when they were presented in context.

Taken together, it appears that the semantic information provided by morphemes may facilitate the orthographic learning of polysyllabic words for children across the reading skill continuum. It also appears that contextual semantic information may interfere with the orthographic learning of polysyllabic words, especially for children with below average reading skills and children with reading difficulty.

4.4 Morphology and Context Effects with Frequency Covariate Analyses

Secondary analyses were conducted to examine whether the effects of morphology and context on the orthographic learning of polysyllabic words in children with and without reading difficulty varied by the frequency of the polysyllabic words. Given that the target pseudowords were matched on the frequency of the base-word, the frequency of the targets was determined based on the frequency of the real and pseudo-suffixes, with words ending with *-ful* and *-bel* given high-frequency designation and words ending with *-ness* and *-rass* given low-frequency designation.

A Mixed-design ANOVA with two levels of word-type (mono-morphemic, polymorphemic) and two levels of frequency (low, high) as within-subject factors, and two levels of condition (isolation, condition) and three levels of reading difficulty status (typical achievement, borderline, reading difficulty) as between-subjects factors was used to examine the composite orthographic learning scores. Two additional identical analyses were carried out for the component orthographic learning measures (the orthographic choice task and the spelling task) in order to detect variations in the quality of the acquired whole-word representations as it relates to frequency. The results of the three analyses are summarized in this section.

4.4.1 Composite Orthographic Learning Score Analysis

The results of the ANOVA concerning the composite orthographic learning score with frequency covariate is presented in Table 17. The results of this analysis mirrored the results of the earlier analysis without frequency covariate. The analysis yielded a significant main effect for word-type, a significant main effect for condition, and a marginally significant effect for the interaction between condition and reading skill (see Table 17). The analysis did not yield a significant main effect for frequency, $F(1, 268) = 0.29$, $p = .590$, $\eta_p^2 = 0.001$, and none of the other main effects or interactions was significant, $F \leq 0.93$, $p \geq .336$, $\eta_p^2 \leq 0.007$.

Table 17: ANOVA for Composite Orthographic Learning Score with Frequency Covariate

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	2.776	1	2.776	4.63	0.032	0.017
Frequency	0.174	1	0.174	0.29	0.590	0.001
Condition	6.412	1	6.412	10.7	0.001	0.038
Reading Skill	0.069	2	0.034	0.06	0.944	0.000
Word-type x Frequency	0.474	1	0.474	0.79	0.375	0.003
Word-type x Condition	0.003	1	0.003	0.00	0.946	0.000
Word-type x Reading Skill	0.451	2	0.225	0.38	0.687	0.003
Frequency x Condition	0.557	1	0.557	0.93	0.336	0.003
Reading Skill x Frequency	0.965	2	0.482	0.80	0.448	0.006
Condition x Reading Skill	3.005	2	1.503	2.51	0.083	0.018
Word-type x Frequency x Condition	0.201	1	0.201	0.34	0.563	0.001
Word-type x Frequency x Reading Skill	0.268	2	0.134	0.22	0.800	0.002
Frequency x Condition x Reading Skill	1.210	2	0.605	1.01	0.366	0.007
Reading Skill x Word-type x Condition	0.662	2	0.331	0.55	0.577	0.004
Word-type x Frequency x Condition x Reading Skill	0.003	2	0.001	0.00	0.998	0.000
Error	161	268	0.599			
Total	176	291	0.605			

Overall, the results of this analysis indicate that morphology facilitate the orthographic learning of polysyllabic words in children with and without reading difficulty. The results also indicate that the semantic information provided by context interferes with the orthographic learning of polysyllabic words, especially for struggling readers and children with reading difficulty. The results of this analysis did not show neither facilitating nor inhibiting effects of frequency in the orthographic learning of polysyllabic words, as measured by the composite orthographic learning score.

4.4.2 Orthographic Choice Score Analysis

The results of the ANOVA concerning the orthographic choice task with frequency covariate is presented in Table 18. Again, the results of this analysis yielded a significant main effect for condition and a marginally significant interaction between condition and reading skill (see Table 18). This analysis also yielded a significant main effect for frequency, $F(1, 268) = 6.05$, $p = .015$, $\eta_p^2 = 0.022$, with children selecting high-frequency targets more accurately than low-frequency targets, $M = .63$, $SD = .30$ and $M = .58$, $SD = .30$, respectively. None of the other main effects or interactions was significant, $F \leq 2.21$, $p \geq .112$, $\eta_p^2 \leq 0.016$.

Table 18: ANOVA for Orthographic Choice Score with Frequency Covariate

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	0.000	1	0.000	0.00	0.971	0.000
Frequency	0.548	1	0.548	6.05	0.015	0.022
Condition	0.527	1	0.527	5.82	0.017	0.021
Reading Skill	0.133	2	0.066	0.73	0.482	0.005
Word-type x Frequency	0.000	1	0.000	0.01	0.942	0.000
Word-type x Condition	0.183	1	0.183	2.02	0.156	0.007
Word-type x Reading Skill	0.080	2	0.040	0.44	0.643	0.003
Frequency x Condition	0.012	1	0.012	0.13	0.718	0.000
Reading Skill x Frequency	0.400	2	0.200	2.21	0.112	0.016
Condition x Reading Skill	0.514	2	0.257	2.84	0.060	0.021
Word-type x Frequency x Condition	0.110	1	0.110	1.21	0.272	0.005
Word-type x Frequency x Reading Skill	0.075	2	0.037	0.41	0.661	0.003
Frequency x Condition x Reading Skill	0.107	2	0.053	0.59	0.555	0.004
Reading Skill x Word-type x Condition	0.248	2	0.124	1.37	0.256	0.010
Word-type x Frequency x Condition x Reading Skill	0.122	2	0.061	0.68	0.509	0.005
Error	24.25	268	0.090			
Total	26.36	291	0.091			

Overall, the results of this analysis indicate that the semantic information provided by context interferes with the orthographic learning of polysyllabic words, especially for struggling readers and children with reading difficulty. The results also indicate that frequency facilitate the orthographic learning of polysyllabic words in children with and without reading difficulty, irrespective of the morphological structure of the words.

4.4.3 Spelling Score Analysis

The results of the ANOVA analysis concerning the spelling task with frequency covariate is presented in Table 19. The results of this analysis yielded a significant main effect for word-type and for condition (see Table 19). The analysis also yielded a marginally significant main effect of frequency, $F(1, 268) = 2.84$, $p = .093$, $\eta_p^2 = 0.010$, with children spelling low-frequency targets more accurately than high-frequency targets, $M = .24$, $SD = .25$ and $M = .18$, $SD = .25$, respectively. None of the other main effects or interactions was significant, $F \leq 2.50$, $p \geq .115$, $\eta_p^2 \leq 0.012$.

Overall, the results of this analysis indicate that the semantic information provided by morphology facilitates the orthographic learning of polysyllabic words. The results also indicate that the semantic information provided by context interferes with the orthographic learning of polysyllabic words. Additionally, the results indicate a possible inhibiting effect of frequency in the orthographic learning of polysyllabic words. The effects of morphology, context, and frequency appear to be true for children with and without reading difficulty.

Table 19: ANOVA for Spelling Score with Frequency Covariate

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	0.688	1	0.688	11.7	0.001	0.042
Frequency	0.167	1	0.167	2.84	0.093	0.010
Condition	0.445	1	0.445	7.58	0.006	0.027
Reading Skill	0.055	2	0.027	0.46	0.629	0.003
Word-type x Frequency	0.133	1	0.133	2.27	0.134	0.008
Word-type x Condition	0.147	1	0.147	2.50	0.115	0.009
Word-type x Reading Skill	0.031	2	0.016	0.26	0.768	0.002
Frequency x Condition	0.081	1	0.081	1.38	0.241	0.005
Reading Skill x Frequency	0.020	2	0.010	0.17	0.845	0.001
Condition x Reading Skill	0.153	2	0.077	1.30	0.273	0.010
Word-type x Frequency x Condition	0.003	1	0.003	0.04	0.833	0.000
Word-type x Frequency x Reading Skill	0.138	2	0.069	1.17	0.312	0.009
Frequency x Condition x Reading Skill	0.191	2	0.095	1.62	0.199	0.012
Reading Skill x Word-type x Condition	0.123	2	0.061	1.05	0.353	0.008
Word-type x Frequency x Condition x Reading Skill	0.075	2	0.037	0.63	0.531	0.005
Error	15.75	268	0.059			
Total	18.42	291	0.063			

Although only marginally significant, the negative effect of frequency found in the spelling analysis was particularly surprising. A reexamination of the target pseudowords suggested that this unpredicted result may be caused by a design error. As described above, targets were given high-low frequency designation based on the frequency of the real and pseudo-suffixes used to create them. The frequency counts used to determine the frequency of the suffixes were token frequencies for the letter strings comprising the suffixes. When the frequencies for those letter strings were obtained from Zeno et al.'s (1995) EWFG corpus, the search did not specify position-based frequencies. Hence, the token frequency for each letter string represented the number of times it occurred in the database irrespective of the position of the letter string in the word. For example, the token frequency for *-bel-*, included the total number of times it occurred in the beginning of a word (e.g., *belief*), middle of a word (e.g., *sunbelt*), and end of a word (e.g., *label*). As a result, the token frequencies (see Table 20).

Table 20: Frequencies for Target Real and Pseudo Suffixes by Position

Suffix	Initial Position	Medial Position	Final Position	Total
Real suffix				
-ful	922	916	2981	4819
-ness	19	69	1181	1269
Pseudo-suffix				
-bel	3506	144	115	3765
-rass	0	230	945	1175

Given that suffixes appear at the end of the word, using final position token frequency would be more appropriate for selecting real and pseudo-suffixes to create polysyllabic stimuli. As shown in Table 20, in this study, when considering the total token frequencies across positions, *-bel* is a high-frequency letter string and *-rass* is a low frequency letter string. However, when considering the token frequencies for the letter strings in the final position only, *-rass* becomes the high-frequency letter string and *-bel* becomes the low-frequency suffix. Consequently, in this study, targets ending with *-bel* (e.g., *zurtbel*) were mistakenly classified as high-frequency targets and targets ending with *-rass* (e.g., *beelrass*) were mistakenly classified as low-frequency targets.

This error in stimuli design may have a particular influence in the spelling task. While *-bel* might occur in more English words than *-rass*, when added to the end of the word, it violates one of the most commonly taught spelling rules in the early elementary grades states—that is, the role of doubling the consonant letters *F*, *L*, and *S* after a short-vowel or at the end of a closed-syllable (e.g., *boss*, *fulfill*, *confess*, *tariff*). It is possible that, in this study, children who did not acquire fully functional representations of the targets ending with *-ness* and *-rass,* were still able to spell those stimuli correctly based on their knowledge of English sound-letter conversion rules and this spelling rule, resulting in higher spelling scores for the targets classified as low-frequency targets. While it is possible that the high token frequency for *-ful* in final position aided children's decision to whether double the final *l*, the low token frequency for *-bel* in final position made it more susceptible for spelling errors contributing to the low spelling score for the stimuli classified as high-frequency targets.

For more accurate estimation of the frequency effects in the spelling task, the spelling with frequency covariate analysis was re-run with reverse frequency coding for the monomorphemic stimuli (i.e., stimuli ending with *-bel* were considered low in frequency and stimuli ending with *-rass* were considered high in frequency). The results of this analysis are reported below.

4.4.4 Spelling Score Analysis with Adjusted Frequency Counts

The results of the ANOVA concerning the spelling task with adjusted frequency covariate is presented in Table 21. Similar to the results of the prior analysis, the results of this analysis yielded a significant main effect of word-type and for condition (see Table 21). The frequency main effect was not significant, $F(1, 268) = 2.27$, $p = .134$, $\eta_p^2 = 0.008$. However, there was a marginally significant interaction between word-type and frequency, $F(1, 268) = 2.84$, $p = .093$, $\eta_p^2 = 0.010$. None of the other main effects or interactions was significant, $F \leq 2.50$, $p \geq .115$, $\eta_p^2 \leq 0.012$.

Table 21: ANOVA for Spelling Score with Adjusted Frequency Counts

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Word-type	0.688	1	0.688	11.7	0.001	0.042
Frequency	0.133	1	0.133	2.27	0.134	0.008
Condition	0.445	1	0.445	7.58	0.006	0.027
Reading Skill	0.055	2	0.027	0.46	0.629	0.003
Word-type x Frequency	0.167	1	0.167	2.84	0.093	0.010
Word-type x Condition	0.147	1	0.147	2.50	0.115	0.009
Word-type x Reading Skill	0.031	2	0.016	0.26	0.768	0.002
Frequency x Condition	0.003	1	0.003	0.04	0.833	0.000
Reading Skill x Frequency	0.138	2	0.069	1.17	0.312	0.009
Condition x Reading Skill	0.153	2	0.077	1.30	0.273	0.010
Word-type x Frequency x Condition	0.081	1	0.081	1.38	0.241	0.005
Word-type x Frequency x Reading Skill	0.020	2	0.010	0.17	0.845	0.001
Frequency x Condition x Reading Skill	0.075	2	0.037	0.63	0.531	0.005
Reading Skill x Word-type x Condition	0.123	2	0.061	1.05	0.353	0.008
Word-type x Frequency x Condition x Reading Skill	0.191	2	0.095	1.62	0.199	0.012
Error	15.75	268	0.059			
Total	18.42	291	0.063			

The interaction between word-type and frequency was examined through a set of post-estimation contrasts. The contrasts showed a significant small frequency effect on the spelling scores for monomorphemic words, $F(1, 288) = 5.15$, $p = .024$, $d = .433$, but not for polymorphemic words, $F(1, 288) = 0.63$, $p = .428$, $d = .118$. Children spelled high-frequency monomorphemic words more accurately than low-frequency monomorphemic targets. They however, spelled high- and low-frequency polymorphemic targets with equal accuracy. Table 22 presents the spelling scores as a function of word-type and frequency and Figure 5 illustrates this interaction.

Table 22: Performance on the Spelling Task by Word-type and Frequency

Frequency	Word-type: Monomorphemic	Polymorphemic	Overall
Low-frequency			
Mean	0.11	0.29	0.20
SD	(-0.20)	(-0.26)	(-0.25)
High-frequency			
Mean	0.20	0.26	0.23
SD	(-0.22)	(-0.28)	(-0.25)
Overall			
Mean	0.15	0.27	0.21
SD	(-0.21)	(-0.27)	(-0.25)

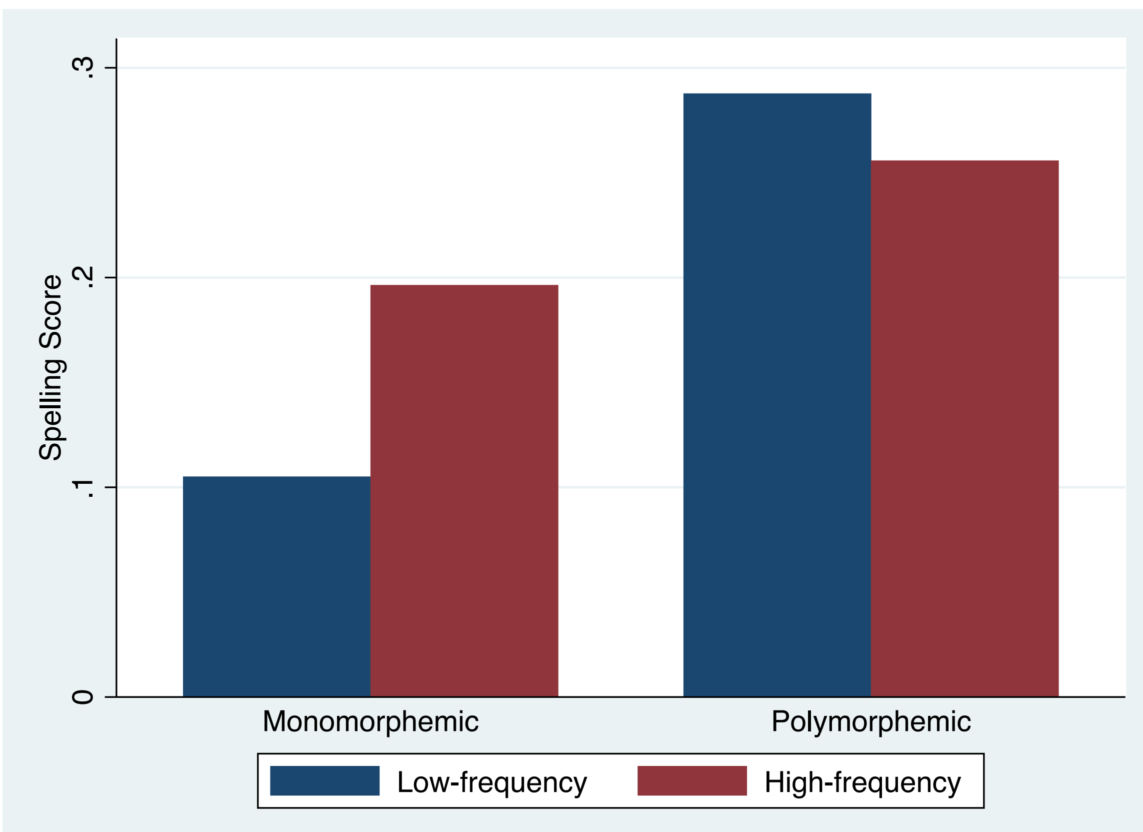

Figure 5: Spelling scores by word-type and frequency.

Overall, the results of this analysis indicate that the semantic information provided by context interfere with the orthographic learning of polysyllabic words. The results also show that frequency may facilitate the orthographic learning of polysyllabic words. However, the facilitating effect of frequency may be moderated by the word-type. It appears that frequency may facilitate the orthographic learning of monomorphemic words but not of polymorphemic words, irrespective of children's reading skill level.

To summarize, four sets of ANOVA analyses examined whether the morphology and context effects in the orthographic learning of polysyllabic words varied by word frequency. The results of these analyses suggest that children, across reading skill groups, acquire higher quality representations of high-frequency polysyllabic words than of low-frequency polysyllabic words. The results also suggest that the facilitating effect of frequency may be particularly important for monomorphemic words, but not for polymorphemic words. The possible frequency effect does not appear to vary by the context in which the polysyllabic words are presented or by children's reading skill.

4.5 Predicting Orthographic Learning Analyses

A set of three multiple linear regression models was used to examine the contributions of phonological decoding skills, morphological knowledge, and orthographic knowledge to the orthographic learning of polysyllabic words, as measured by the composite orthographic learning score. The first model simultaneously regressed the composite orthographic learning score on phonological decoding (as measured by the WRMT3-WA) and morphological knowledge (as measured by the TMS-D and AKT composite score). The second model simultaneously regressed the composite orthographic learning score on phonological decoding, morphological knowledge, and orthographic knowledge (as measured by the OCT and LST composite score). The third model simultaneously regressed the composite orthographic learning score on phonological decoding, morphological knowledge, orthographic knowledge, reading skill (as measured by the composite score of TOWRE-SWE and TOWRE-PDE), and the two-way interactions between reading skill and each of the earlier variables: reading skill x phonological decoding, reading skill x morphological knowledge, and reading skill x orthographic knowledge. Two additional identical sets of regression models were carried out for the component orthographic learning measures (the orthographic choice task and the spelling task) in order to detect variations in the quality of the acquired whole-word representations. The overall R^2 value for each regression model and the contributions of each of the examined variables to the orthographic learning of polysyllabic words are reported below.

4.5.1 Predicting Composite Orthographic Learning Score Analysis

The results of the regression analyses concerning the composite orthographic learning score are presented in Table 23. The regression model with phonological decoding and morphological knowledge explained 26% of the variance in the composite orthographic learning score, $R^2 = .26$, $F(2,70) = 12.09$, $p = .000$. In this model, morphological knowledge was a significant predictor and explained 18% of the variance in the composite orthographic learning score ($p = .000$, $\eta_p^2 = 0.184$). Phonological decoding was only marginally significant and explained 4% of the variance in the composite orthographic learning score (p = .078, $\eta_p^2 = 0.044$).

The regression model with of phonological decoding, morphological knowledge, and orthographic knowledge explained 30% of the variance in the composite orthographic learning score, $R^2 = .30$, $F(3,69) = 9.81$, $p = .000$, $\Delta R^2 = .04$, $F(1, 69) = 4.16$, $p = .045$. In this model, both morphological knowledge and orthographic knowledge were significant predictors of the composite orthographic learning score, explaining 10% ($p = .009$, $\eta_p^2 = 0.096$) and 6% of the variance in the composite orthographic learning score ($p = .045$, $\eta_p^2 = 0.057$), respectively. Phonological decoding was no longer a significant predictor of the composite orthographic learning score, ($p = .340$, $\eta_p^2 = 0.013$).

The regression model with reading skill and its interaction with phonological decoding, morphological knowledge, and orthographic knowledge explained 37% of the variance in the composite orthographic learning score, $R^2 = .37$, $F(7,65) = 5.46$, $p = .000$, $\Delta R^2 = 0.07$, $F(4, 65) = 1.84$, $p = .132$. In this model, phonological decoding, morphological knowledge, and reading skill were significant predictors of the composite orthographic learning score, explaining 7% ($p = .029$, $\eta_p^2 = 0.071$), 11% ($p = .008$, $\eta_p^2 = 0.105$), and 6% ($p = .041$, $\eta_p^2 = 0.063$) of the variance in the composite orthographic learning score, respectively. Orthographic knowledge was only marginally significant and explained 5% of the variance in the composite orthographic learning score ($p = .062$, $\eta_p^2 = 0.052$). The reading skill did not interact with any of the other predictors in the model, $p \geq .302$, $\eta_p^2 \leq 0.016$.

Table 23: Predicting Composite Orthographic Learning Score

Variable	Model 1			Model 2			Model 3		
	Coef.	*SE*	η_p^2	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2
Intercept	0.000	0.086		0.000	0.084		-0.035	0.093	
PD	0.160	0.090†	0.044	0.091	0.094	0.013	0.244	0.110*	0.071
MK	0.396	0.099***	0.184	0.295	0.109**	0.096	0.304	0.110**	0.105
OK				0.264	0.130*	0.057	0.267	0.141†	0.052
RS							-0.219	0.105*	0.063
RS x PD							0.076	0.096	0.010
RS x MK							0.139	0.134	0.016
RS x OK							-0.120	0.139	0.011
R^2	0.26			0.3			0.37		
ΔR^2				0.04			0.07		
F for ΔR^2	12.1***			4.16*			1.84		

Note. PD = phonological decoding; MK = morphological knowledge; OK = orthographic knowledge; RS = reading skill.
$^{\dagger}p \leq .10$. $^{*}p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

Taken together, the results of this set of regression analyses indicate that morphological knowledge contributes to the orthographic learning of polysyllabic words, above and beyond the contribution of phonological decoding skills and orthographic knowledge. Controlling for phonological decoding skills, orthographic knowledge, and reading skill, morphological knowledge appears to be the most robust predictor of the composite orthographic learning score for children across the reading skill continuum. The results also indicate that orthographic knowledge may also contribute to children's orthographic learning of polysyllabic words, irrespective of their reading skill. Additionally, the results of these analyses suggest that children's reading skill contributes to their orthographic learning of polysyllabic words.

4.5.2 Predicting Orthographic Choice Score Analysis

The results of the regression analyses concerning the orthographic choice task are presented in Table 24. The regression model with phonological decoding and morphological knowledge explained 18% of the variance in orthographic choice score, $R^2 = .18$, $F(2,70) = 7.43$, $p = .001$. In this model, morphological knowledge was the only significant predictor, explaining 16% of the variance in orthographic choice score ($p = .001$, $\eta_p^2 = 0.157$). Phonological decoding was not a significant predictor of orthographic choice score, ($p = .712$, $\eta_p^2 = 0.002$).

The regression model with phonological decoding, morphological knowledge skill, and orthographic knowledge explained 22% of the variance in orthographic choice score, $R^2 = .22$, $F(3,69) = 6.33$, $p = .001$, $\Delta R^2 = .04$, $F(1, 69) = 3.59$, $p = .062$. In this model, morphological knowledge was the only significant predictor, explaining 8% of the variance in orthographic choice score ($p = .018$, $\eta_p^2 = 0.079$). Orthographic knowledge was only a marginally significant predictor and explained 5% of the variance in orthographic choice score ($p = .062$, $\eta_p^2 = 0.049$). Phonological decoding remained a non-significant predictor of orthographic choice score, ($p = .738$, $\eta_p^2 = 0.002$).

The regression model with reading skill and its interaction with phonological decoding skill, morphological knowledge and orthographic knowledge explained 35% of the variance in orthographic choice score, $R^2 = .35$, $F(7,65) = 4.94$, $p = .000$, $\Delta R^2 = 0.13$, $F(4, 65) = 3.27$, $p = .017$. In this model, both morphological knowledge and reading skill were significant predictors, explaining 10% ($p = .009$, $\eta_p^2 = 0.099$) and 8% ($p = .021$,

η_p^2 = 0.079) of the variance in orthographic choice score, respectively. Orthographic knowledge was again a marginally significant predictor and explained 4% of the variance in orthographic choice score (p = .102, η_p^2 = 0.041). In this model, there was also a marginally significant interaction between phonological decoding and reading skill, explaining 4% of the variance in orthographic choice score (p = .089, η_p^2 = 0.044). None of the other interactions were statistically significant, $p \geq .140$, $\eta_p^2 \leq 0.033$.

Table 24: Predicting Orthographic Choice Score

Variable	Model 1			Model 2			Model 3		
	Coef.	*SE*	η_p^2	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2
Intercept	0.603	0.019***		0.603	0.019***		0.587	0.020***	
PD	0.007	0.020	0.002	-0.007	0.021	0.002	0.038	0.023	0.039
MK	0.079	0.022***	0.157	0.058	0.024**	0.079	0.063	0.023**	0.099
OK				0.054	0.029†	0.049	0.050	0.030†	0.041
RS							-0.053	0.022*	0.079
RS x PD							0.035	0.020†	0.044
RS x MK							0.042	0.028	0.033
RS x OK							-0.042	0.030	0.029
R^2	0.18			0.22			0.35		
ΔR^2				0.04			0.13		
F for ΔR^2	7.43***			3.59†			3.27*		

Note. PD = phonological decoding; MK = morphological knowledge; OK = orthographic knowledge; RS = reading skill.
$^{\dagger}p \leq .10$. $^{*}p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

Taken together, the results of this set of regression analyses indicate that morphological knowledge contributes to the orthographic learning of polysyllabic words, above and beyond the contribution of phonological decoding skills and orthographic knowledge. The results also indicate that orthographic knowledge and reading skill contribute uniquely to the orthographic learning of polysyllabic words. Additionally, the results indicate that the contribution of phonological decoding to the orthographic learning of polysyllabic words may vary by children's reading skill.

4.5.3 Predicting Spelling Score Analysis

The results of the regression analyses concerning the spelling task are presented in Table 25. The regression model with phonological decoding and morphological knowledge explained 22% of the variance in spelling, $R^2 = .22$, $F(2,70) = 9.70$, $p = .000$. In this model, both phonological decoding and morphological knowledge were significant predictors of spelling score. Phonological decoding explained 9% of the variance in spelling score ($p = .013$, $\eta_p^2 = 0.085$), and morphological knowledge explained 10% of the variance of spelling score ($p = .006$, $\eta_p^2 = 0.102$).

The regression model with phonological decoding, morphological knowledge skill, and orthographic knowledge explained 24% of the variance in spelling score, $R^2 = .24$, $F(3,69) = 7.18$, $p = .000$, $\Delta R^2 = .02$, $F(1, 69) = 1.90$, $p = .173$. In this model, both phonological decoding and morphological knowledge were marginally significant predictors of spelling score. Phonological decoding explained 5% of the variance in spelling score ($p = .062$, $\eta_p^2 = 0.049$). Morphological knowledge also explained 5% of the variance in spelling score ($p = .060$, $\eta_p^2 = 0.050$). Orthographic knowledge, however, was not a significant predictor of spelling score ($p = .173$, $\eta_p^2 = 0.027$).

The spelling model including Reading difficulty and its interaction with phonological decoding skill, morphological knowledge and orthographic knowledge skill explained 25% of the variance in spelling score, $R^2 = .25$, $F(7,65) = 3.15$, $p = .006$,

$\Delta R^2 = 0.01$, $F(4, 65) = 0.33$, $p = .859$. In this model, both phonological decoding and morphological knowledge were marginally significant predictors of spelling score. Phonological decoding explained 5% of the variance in spelling score ($p = .058$, $\eta_p^2 = 0.054$). Morphological knowledge also explained 5% of the variance in spelling score ($p = .081$, $\eta_p^2 = 0.046$). Orthographic knowledge remained a non-significant predictor of spelling score ($p = .171$, $\eta_p^2 = 0.029$). Neither reading skill nor any of its interactions was a significant predictor of spelling score, $p \geq .309$, $\eta_p^2 \leq 0.016$.

Table 25: Predicting Spelling Score

Variable	Model 1			Model 2			Model 3		
	Coef.	*SE*	η_p^2	*Coef.*	*SE*	η_p^2	*Coef.*	*SE*	η_p^2
Intercept	0.211	0.014^{***}		0.211	0.014^{***}		0.214	0.016^{***}	
PD	0.037	0.014^{**}	0.085	0.029	$0.015^{\dagger}$	0.049	0.036	$0.019^{\dagger}$	0.054
MK	0.045	0.016^{**}	0.102	0.034	$0.018^{\dagger}$	0.050	0.033	$0.019^{\dagger}$	0.046
OK				0.029	0.021	0.027	0.033	0.024	0.029
RS							-0.018	0.018	0.016
RS x PA							-0.006	0.016	0.002
RS x MK							0.005	0.023	0.001
RS x OK							0.000	0.024	0.000
R^2	0.22			0.24			0.25		
ΔR^2				0.02			0.01		
F for ΔR^2	9.70^{***}			1.90			0.33		

Note. PD = phonological decoding; MK = morphological knowledge; OK = orthographic knowledge; RS = reading skill.
$^{\dagger}p \leq .10$. $^{*}p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

Taken together, the results of this set of regression analyses indicate that phonological decoding skills and morphological knowledge contribute uniquely to the orthographic learning of polysyllabic words. The contributions of phonological decoding skills and morphological knowledge do not appear to vary by children's reading skill.

To summarize, three sets of regression models examined predictors of the orthographic learning of polysyllabic words. The results of these analyses indicate that, controlling for phonological decoding skills and orthographic knowledge, morphological knowledge emerges as a robust predictor of the orthographic learning of polysyllabic words, irrespective of children's reading skill. The results also indicate that the contribution of phonological decoding skills, orthographic knowledge, and reading skill to the orthographic learning of polysyllabic words may vary by orthographic learning task. It appears that while orthographic knowledge and reading skill contribute to the visual recognition of polysyllabic words, measured using an orthographic choice task, only phonological decoding skills contribute to the production of polysyllabic words, as measured using a spelling task.

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

5.1 Overview

To review, this orthographic learning study used a modified version of Share's (1999) self-teaching study design to investigate how children acquire whole-word orthographic representations of polysyllabic words. Polysyllabic words constitute a large number of the words children in middle and upper elementary grades encounter in content-area texts. Accurate and rapid identification of polysyllabic words through direct access to their orthographic representations, or the lack thereof, could influence children's reading comprehension greatly. However, the orthographic learning literature has, thus far, focused on examining the acquisition of whole-word representations of monosyllabic words, which differ greatly in their phonological and orthographic characteristic from polysyllabic words. The purpose of this study was to address this gap in the orthographic learning literature by examining factors that could influence the orthographic learning of polysyllabic words—namely, morphology and context.

This study was motivated, in part, by the lack of clarity about the relevant efficacy of two current approaches to teaching polysyllabic word reading: syllabication and morphological decomposition. Although not an intervention study, this study could provide invaluable information about the relative importance of instructional approaches that emphasize meaning, through morphological analysis and the use of contextual information, and instructional approaches that emphasize syllable division rules. At minimum, the findings of this study could improve our understanding of how children across the reading skill continuum access, store, and retrieve orthographic the forms of polysyllabic words.

I begin this chapter by summarizing the findings of this study. I then discuss the study key findings as they relate to the study research questions and the current orthographic learning literature. I follow with a discussion of the educational implications to the findings of this study and a discussion of the limitations to these findings, and conclude with recommendations for future research.

5.2 Summary of Results

The data analyzed in this study were obtained from a group of fourth and fifth grade children with and without reading difficulty. The children completed an orthographic learning task in which they read disyllabic (monomorphemic and dimorphemic) pseudowords in isolation or embedded in short stories. The children then completed two orthographic learning measures: orthographic choice and spelling. The orthographic choice task measured children's ability to visually identify the target pseudowords. The results of the orthographic choice task showed orthographic learning levels well above the chance level of 25%. The spelling task measured children's ability to reproduce the target pseudowords. The results of the spelling task failed to show orthographic learning above the chance level of %50. In fact, children's performance in the spelling task appeared to be at floor level, irrespective of children's reading skill. Nevertheless, the planned analyses were carried out and both, the orthographic choice data and the spelling data, were examined for patterns of semantic influences in the orthographic learning of polysyllabic words. It must be noted however, that the differences in the evidence for orthographic learning produced by the orthographic choice task and the spelling task are consistent with the findings of Cunningham (2006) who also reported evidence for orthographic leaning in the orthographic choice task but not in the spelling task. These differences may suggest that the orthographic representations that the children acquired where sufficient for visual word identification but were not high in quality enough to produce correct spellings.

The first research question asked whether children acquire higher quality whole-word representations of printed polysyllabic words when presented in context and with an emphasis on morphemes, versus in isolation and with an emphasis on syllables; and whether the patterns of acquisition vary by children's reading skill. To answer this question, the orthographic choice scores, the spelling scores, and their composite scores were analyzed using three separate ANOVA models. The results of the composite orthographic learning score indicated that context interfered with the orthographic learning of the target pseudowords and indicated that context interference varied by children's reading skill. That is, context interfered with the orthographic learning of the target pseudowords in struggling readers and children with reading difficulty but not in typically achieving readers. The results also indicated that the semantic information provided by morphemes facilitated the orthographic learning of the target pseudowords. The results of the individual orthographic choice and spelling analyses indicated that reading skill moderated context interference in the orthographic choice task but not in the spelling task. The results of the individual analyses also indicated that morphology only facilitated the orthographic learning in the spelling task but not in the orthographic choice task.

Additional analyses were carried out to assess whether the frequency of the morpheme (real and pseudo) moderate the detected context and morphology effects. The results of the composite orthographic learning score did not detect any frequency effects. The results of the orthographic choice task indicated that high-frequency real and pseudo-morphemes facilitated the orthographic learning of the target pseudowords. The results of two spelling analyses indicated that frequency may moderate the effect of morphology—that is, high-frequency may facilitate the orthographic learning of morphemic words but not polymorphemic words. However, this finding was only marginally significant and might have been influenced by errors in stimuli design and will not be discussed further. Overall, the results of the analyses aimed at answering the first question indicated that context interfered with the orthographic learning of the target polysyllabic pseudowords, at least in struggling readers and children with reading difficult. The results also indicated that morphology facilitated the orthographic learning of the target polysyllabic pseudowords.

The second research question asked whether morphological knowledge contributes to the acquisition of whole-word representations of polysyllabic words above and beyond phonological decoding skill and orthographic knowledge, and whether the contributions of morphological knowledge vary by children's reading skill. To answer this question, the three orthographic learning scores were analyzed using three separate sets of multiple linear regression models. The results of the three sets of analyses indicated that morphological knowledge contributed to the orthographic learning of the target pseudowords in children with and without reading difficulty, even in the presence of phonological decoding and orthographic knowledge. Although phonological decoding contributed to the prediction of the composite orthographic learning scores, the individual orthographic choice and spelling analyses indicated that phonological decoding only contributed to the prediction of the spelling scores but not the orthographic choice scores. Orthographic knowledge, however, contributed to the prediction of the composite orthographic learning scores and the orthographic choice scores but not the spelling scores. Similarly, reading skill contributed to the prediction of the composite orthographic learning scores and the orthographic choice scores but not the spelling scores. In fact, the results of the orthographic choice analyses suggested that the contribution of phonological decoding in the orthographic learning of the target pseudowords may have been moderated by children's reading skill. Overall, the results of the regression analyses aimed at answering the second research question indicated that morphological knowledge was the most constant and important predictor of the orthographic learning of the target polysyllabic pseudowords.

5. 3 Key Findings

5.3.1 Context Effects

One of the main goals of this study was to examine whether the semantic information provided by context enriches the meaning of newly encountered polysyllabic words and facilitates the acquisition of high-quality representations of those words. A key finding of this study was that contextual semantic information did not facilitate the orthographic learning of the target polysyllabic pseudowords. In fact, context appeared to interfere with the orthographic learning of polysyllabic words. Overall, children enrolled in the isolation condition appeared to have acquired higher-quality orthographic representations of the target pseudowords than those enrolled in the context condition. While this study started with the hypothesis that the contextual semantic information may facilitate the formation of high-quality orthographic representations of polysyllabic words, the findings of inhibiting context effects are not surprising given that processing text is cognitively demanding. Similar to the findings of Landi et al. (2006), the findings of this study suggest that reading connected text requires increased attention to the semantic information in the text and limits the attention available to acquire word-specific orthographic forms.

When considering the existent literature concerning the effects of contextual semantic information on the orthographic learning of monosyllabic English words, the finding of negative context effects in this study are consistent with the findings of a number of studies—namely, Landi et al. (2006), Nation et al. (2007), and Ricketts et al. (2011). However, this finding contradicts with the findings of a number of other studies that reported facilitating effects of context in the orthographic learning of monosyllabic English words—namely, Ouellette, (2010), Ouellette and Fraser (2009), and Wang et al. (2011). At first glance, the context related findings reported in this study and in the orthographic learning literature are inconsistent. However, a careful examination of the literature reveals a wide variety in the way contextual semantic information has been conceptualized in the orthographic learning literature.

Notably, similar to this study, the studies that found no or negative context effects used orthographic learning tasks that required children to read novel words embedded in short stories while the studies that found positive context effects used orthographic learning tasks that involved providing short definitions and illustrations of the target words (see Ouellette & Fraser, 2009, p. 250 for an example). The variety of tasks employed in the context condition may be the cause of the inconsistent findings regarding context effects in the literature. While presenting the novel words embedded in short stories simulated natural text reading, providing definition and illustrations simulated pre-reading vocabulary instruction. In the tasks involving reading the target words embedded in short stories, children had to deduce the meaning of the novel words using context clues. However, in the tasks involving vocabulary pre-teaching, children were provided with word-specific semantic information as well as visual representations of the words. In a way, children who received definitions and illustrations of the target words had an advantage over the children who had to deduce the meaning from the information surrounding the words in the text. It appears that context clues alone do not facilitate the orthographic learning of new words. However, pre-teaching the words provides children with mental representations of the words' meaning, which in turn facilitates orthographic learning.

An additional goal of this study was to examine whether context effects vary by reading skill. The small number of poor readers in this study, compared to the number of typically developing readers (n =18 versus n = 55), reduced the power to detect significant differences based on reading skill. However, the results of this study showed a clear trend of negative context effects in poor readers but not in typically achieving readers. The quality of the orthographic representations in typically achieving readers do not appear to be influenced by the context in which the words are presented. Less skilled readers and children with reading difficulty, however, appear to acquire higher orthographic representations of words when they are presented in isolation than when they are presented in context. It appears that context interferes with or limits the quality of the orthographic representations acquired by poor readers. This difference in context effects between skilled and poor readers is aligned with the interactive-compensatory model of reading, which posits that because reading requires the simultaneous processing of information at the word and text level, weakness in one skill maybe compensated for by a greater reliance on another skill (Stanovich, 1980; Stanovich & West, 1983).

Typically achieving readers have efficient decoding and word recognition skills and do not rely on context to aid word recognition, reducing the cognitive demands of text reading (Stanovich, 1982). Typical readers can use their limited cognitive resources efficiently to simultaneously process word form and meaning, resulting in comparable orthographic learning patterns for words presented in isolation and context alike. As Yuill and Oakhill (1991) noted, skilled readers “are more sensitive to context, but are less dependent on it to aid word recognition, because their decoding is too fast and automatic for context to have an effect." (p. 27). On the contrary, because of their poor decoding skills, poor readers tend to rely on context to compensate for poor their slow and laborious decoding, resulting in more contextual guessing during text reading (Stanovich, 1980; Stanovich & West, 1983). When poor readers rely on context to aid word recognition, they focus on selecting semantically appropriate words given the context clues rather than decoding the words through letter-sound conversion strategy. When children utilize a compensatory strategy like contextual guessing rather than phonological decoding to aid their word recognition, their attention to word form is limited resulting in poorer acquisition of word-specific representations, hence the negative context effects. When poor readers are presented with words in isolation, they are forced to read them using phonological decoding. Although inefficient, their phonological decoding of the words increases their attention to the orthographic details of the words resulting in acquiring higher quality representations for the words than when they are presented in context.

5.3.2 Morphology Effects

One of the main goals of this study was to examine whether the morphemes provide sufficient semantic information to facilitate the orthographic learning of polysyllabic words, and whether morphological knowledge contributes to the orthographic learning of polysyllabic words. A key finding in this study is that morphemes appear to facilitate the orthographic learning of polysyllabic words. In this study, overall, children across the reading skill continuum had higher orthographic learning scores of polysyllabic-polymorphemic words than for polysyllabic-monomorphemic words. This morphology-related finding suggests that children do utilize morphological analysis approach to identify, pronounce, store, and retrieve polysyllabic words.

This finding appears to support the notion that morphology is explicitly represented in the mental lexicon and is activated during the process of acquiring orthographic representations of new words, which contradicts with the findings of Al Ghanem et al. (2015) and Tucker et al. (2016) who reported no effects of morphology in the orthographic learning of polysyllabic words. The findings of Al Ghanem et al. (2015) and Tucker et al. (2016) suggest that orthographic learning is aided by orthographic overlap rather than morphological one. Tucker et al. (2016) argued that children acquire whole-word representations of polysyllabic words through orthographic analogy strategy that may or may not utilize semantic information. The limited data concerning the role of morphology in the orthographic learning of polysyllabic words limit the interpretability of the findings of this study. More studies are needed to confirm the facilitating effect of morphology in the orthographic learning of polysyllabic words.

Another morphology-related key finding in this study relates to the contributions of morphological knowledge to the orthographic learning of polysyllabic words. The findings of this study suggest that morphological knowledge contributes uniquely to the orthographic learning of polysyllabic words. In this study, morphological knowledge emerged as a robust predictor of the orthographic learning of polysyllabic words in children across the reading skill continuum, above and beyond phonological decoding skill and orthographic knowledge.

In the orthographic learning literature concerning the orthographic learning of monosyllabic words, orthographic learning appears to be largely determined by children's phonological decoding skills (Ricketts et al., 2011; Cunningham et al., 2002), and orthographic knowledge (Cunningham, 2006; Cunningham et al., 2002). This does not appear to be the case in the orthographic learning of polysyllabic words. In this study, phonological decoding only contributed to orthographic learning in the spelling score analyses and orthographic knowledge only contributed to orthographic learning in the orthographic choice score analyses. Morphological knowledge explained the largest portion of the variance in orthographic learning across the three orthographic learning scores.

The emergence of morphological knowledge as a strong predictor of the orthographic learning of polysyllabic confirms that children utilize a morphological analysis strategy to pronounce, store, and retrieve polysyllabic words. Although not examined in other orthographic learning studies, the significant contributions of morphological knowledge to the orthographic learning of polysyllabic words found in this study are aligned with the findings of descriptive studies examining polysyllabic word reading, namely, the finding of increasing contributions of morphological knowledge and the decreasing contributions of phonological decoding skills to the accuracy of polysyllabic word reading (e.g., Kearns, 2015).

In considering the large role of morphological knowledge and the small roles of phonological decoding and orthographic knowledge in the orthographic learning of polysyllabic words, it must be noted that morphological activation happens during the phonological decoding process. As children become more proficient readers, they use larger orthographic units (such as roots and affixes) to identify and pronounce words (Ehri, 1992). Morphological processing happens during phonological decoding and involves activating the orthographic, phonological, semantic, and syntactic characteristics of roots and affixes (Carlisle, 2003). Hence, the orthographic and phonological overlap do not rule out a greater role of both phonological decoding and orthographic knowledge in the orthographic learning of polysyllabic words. More studies are needed to confirm the finding of a large role of morphological knowledge in the orthographic learning of polysyllabic words. More studies are also needed to clarify the independent roles of phonological decoding and orthographic knowledge in the orthographic learning of polysyllabic words.

An additional goal of this study was to examine whether the contributions of morphological knowledge in the orthographic learning of polysyllabic words varied by children's reading skill. Again, it appears that the small sample size of poor readers, compared to skill readers, may have reduced the possibility of detecting significant differences among children of varied reading skill levels. As it stands now, the results of this study indicate that morphological knowledge skill has comparable contributions in the orthographic learning of polysyllabic words across reading skill levels. This is particularly surprising given the documented poor morphological knowledge in children with reading difficulties (Carlisle, 1987) and given the possibility of poor readers continuing to rely on phonological decoding strategy, as a compensatory strategy, to identify and pronounce words. Indeed, the results of this study provided suggestive evidence that the role of phonological decoding in the orthographic learning of polysyllabic words varied by children's reading skill. A finding that warns further examination in future studies. Additional studies are surely required to examine differences in the orthographic learning of polysyllabic words in children with and without reading difficulty.

5.4 Educational Implications

This study was, in part, motivated by the lack of clarity about the relative efficacy of two instructional approaches to polysyllabic word recognition: syllabication and morphological decomposition. Though not an intervention study and not conducted in the context of classroom, this study provides information about critical factors related to the acquisition of whole-word representations of polysyllabic words that may be of instructional importance.

First, the findings of this study support the hypothesis that reading texts is cognitively demanding. Relying on context clues as a word recognition strategy, rather than phonological decoding, can result in poorly specified representations of newly encountered words, especially for children with reading difficulties. Given that context may interfere with children's ability to acquire high-quality orthographic representations of newly encountered words, teachers may elect to introduce new words in isolation rather than embedded in context. While context clues can support comprehension, they are unreliable source for orthographic learning. Teachers must select the instructional strategy that fits the goal of instruction and presenting words in isolation appears to be the most beneficial when the goal of instruction is acquiring word-specific representations.

Second, the findings of this study do not appear to support syllable-based reading instruction. Children appear to benefit from the semantic information provided by morphemes, suggesting that morphology-based reading programs with morphology components that emphasize form and meaning may be more beneficial when teaching polysyllabic word reading.

Moreover, it appears that children's general morphological knowledge has a unique contribution in the orthographic learning of polysyllabic words. This suggests that children may benefit from morphology-focused instruction that aims to improve their general morphological knowledge. Instruction that aims at building children's knowledge of roots and affixes as well as the semantic and syntactic aspects of morphology, the skills assessed in the morphological measures used in this study, may be beneficial.

Although the findings of this study appear to support the use of morphology-based instruction, this study cannot recommend specific morphology-based instructional strategies beyond recommending the emphasis of meaning as it relates to morphemes. Even reading intervention studies have yet to determine the most effective morphology-based instructional approaches. Goodwin and Ahn (2010), and Goodwin and Ahn (2013) reported the results of meta-analyses that aimed at determining the efficacy of various components of morphology instruction. They concluded that the effects of a given morphology instruction varied by target literacy outcome (see Goodwin & Ahn, 2010 and Goodwin & Ahn, 2013 for review). They, however, concluded that teachers should provide morphology instruction as a part of comprehensive intervention program rather than a sole focus. Carlisle (2010), however, outlined four critical components of effective morphology instruction programs: (1) include activities that improve children's awareness of the morphological structure of words, (2) include teaching the meanings of common roots and affixes, (3) include using analogical reasoning for morphological problem solving, and (4) include repeated and varied practicing of morphological analysis.

To summarize, this study contributes to the literature by demonstrating the robust effects of morphology and morphological knowledge in the acquisition of whole-word representations of polysyllabic words. A finding that suggests it may be beneficial for teachers to utilize reading strategies that (1) draw children's attention to the morphological composition of polysyllabic words, (2) emphasize morphological decomposition to identify, pronounce, and deduce the meaning of new words, and (3) teach children common or high frequency roots and affixes with emphasis on meaning rather than word form. It must be noted, however, that syllable-based instructional approaches may be useful, especially that some polysyllabic words are monomorphemic.

5.5 Limitations of the Study

The findings of this study should be interpreted with caution due to a number of limitations related to population and study design. In terms of population, the participants in this study were highly homogenous in their linguistic background. All participants spoke English as a native language. The findings of this study may not apply to English language learners, especially as English language learners may have poorer phonological decoding skills, morphological knowledge, and vocabulary, compared to their native English-speaking peers.

Given that phonological decoding is the pathway to orthographic learning, poor phonological decoding skills may limit English language learners' ability to acquire whole-word representations through phonological decoding. Schwartz, Khan-Horwitz, and Share (2014) showed that English language learners have poor phonological decoding skills and argued that English language learners' orthographic learning skills are influenced by the orthographic proximity between their native language and English as well as their literacy skills in their native language. Schwartz et al. (2014) attempted to examine orthographic learning in English language learners in a group of Russian-Hebrew and Hebrew only speakers. A sub-group of the Russian-Hebrew speaking children was bilingual but not biliterate (that is, they spoke the two languages but only had literacy skills in one of the languages). Schwartz et al. (2014) reported that all groups of children showed evidence of orthographic learning. However, they all had phonological decoding accuracy rates lower than those reported for native English speakers (50% vs. 70%). They also reported that the children who were literate in Russian had greater orthographic learning in English than those who only spoke Russian but did not read it, and greater than the Hebrew only group. Schwartz et al. (2014) concluded that the orthographic proximity between Russian and English in addition to their developed phonological decoding skills in Russian helped the Russian literate children. However, the orthographic distance between Hebrew and English led to greater difficulties in phonological decoding and in acquiring word-specific representations in

English.

Schwartz et al.'s (2014) findings give a glimpse about the possible orthographic learning profiles of English language learners, yet the lack of a native English-speaking children group in the study limits the generalizability of its findings. Nevertheless, the findings support the hypothesis that poor phonological decoding may limit English language learners' orthographic learning skills. This hypothesis can also be extended to poor morphological knowledge in English language learners may result in different patterns in the relation between morphological knowledge and the orthographic learning of polysyllabic words. Additionally, English language learners' relatively impoverished vocabulary may result in different patterns in the effects of context in the orthographic learning of polysyllabic words. If the negative effects of context are the result of contextual guessing as a compensatory strategy for poor phonological decoding skills, poor vocabulary limits the ability to rely on contextual guessing and force a greater reliance on phonological decoding. Greater reliance on phonological decoding may reduce the negative effects of context observed in the orthographic learning of native English-speaking children. To sum up, the findings of this study may reflect idiosyncrasies of native English-speaking children and may not extend to children whom English for is not a native language or have limited English language skills.

A second population related factor that may be a limitation of this study is the small number of children with borderline and reading difficulty profiles in the sample, compared to the number of typically developing readers. The small sample size of these two groups of readers might have reduced the power to detect significant relations between the study variables. A replication of the study with a more equal distribution of reading skill groups is required to confirm the lack of individual differences in the impact of morphology and morphological knowledge skill, among other factors, on the orthographic learning of polysyllabic words.

In terms of study design, one limitation may be the administration of the two orthographic learning measures (spelling and orthographic choice) in the same session. Although separated by a minimum of 25 minutes, it is possible that completing the spelling task early in the session have priming effects on the orthographic choice task. Instead of complete recall for words' orthographic, phonological, and semantic representations from memory, at minimum, the spelling task might have activated the phonological representations of the words and helped children eliminate some orthographic choice answers that did not approximate the activated phonological representations. One possible solution for this problem in future studies is to use different measures for different stimuli. That is, measuring the orthographic learning of half of the stimuli using the orthographic choice task and the other half using the spelling task. It is also possible to utilize one orthographic learning measure, orthographic choice if the study aims to assess visual identification and spelling if the study aims to assess functional representations that allow for the accurate reproduction of the newly learned words.

A second study design limitation is, as described earlier, selecting suffixes and final syllables based on total token frequencies instead of position-bound frequencies. This might have moderated the frequency effects, especially for the monomorphemic words, and especially for the spelling task. The adjusted spelling analysis addressed one possible effect of this stimuli design error. However, other possibilities may exist and the results of the analyses with frequency variable should be interpreted with caution.

A third study design limitation is that children were not asked to define or explain the meaning of the stimuli. Also, they were not asked comprehension questions for context condition stories or asked to explain their word-nonword decision in the isolation condition. Hence, the interpretations of semantic effects may reflect more of theoretical assumptions based on the knowledge of the English language, English orthography, and how children achieve word recognition, and are not supported by analyses of semantic-specific measures.

A fourth study design limitation is the lack of standardization in the administration of the spelling task. The test administrator dictated the words for the spelling task by reading them for each child. Although it was the same administrator, it is possible that the administrator's pronunciation had some allophonic variations, especially in vowel sound pronunciations, and especially that stimuli were pseudowords so no prior phonological reference existed in the tester's lexicon. Additionally, although highly proficient in English, the test administrator was not a native English speaker. This might have also resulted in some allophonic variations. Hence, children's spelling of target words may have been influenced by variations in the pronunciation of the stimuli read to them. The quality of word-specific representations of the target words after three readings only might have not been strong enough to be resistant to or overcome minimal pronunciation variations, although Share (2004) has observed that Hebrew speaking children acquired durable representations after one encounter only. Notably, the spelling scores in this study were generally low, possibly reflecting measurement error, polysyllabic words idiosyncrasies, sound-spelling irregularities in English, or a combination of two or more of these factors. A replication of this study with standardized pronunciation of stimuli in the administration of the spelling task is required to confirm the findings in this study based on the spelling task as an index for the orthographic learning of polysyllabic words.

The last study design limitation is that the study did not consider the possible effects of prior and current reading instruction. Children often use the reading strategies they are taught—strategies teachers use to teach them to read (Carr, Brown, Vavrus, & Evans, 1990). Informal data from the teachers of the children participating in this study indicated a focus on teaching roots and affixes and limited phonological awareness and phonics instruction. The type of reading instruction the children received might have, in part, given the rise in morphology effects observed in this study. Future studies should include systematic data collection concerning the prior and current reading instruction to determine to which degree the morphology effects in orthographic learning reflect inherent orthography and child characteristics versus instructional effects.

While the limitations discussed in this section suggest that caution must be taking when interpreting the findings of this study, this study contributes to the English polysyllabic word and orthographic learning literatures by laying the groundwork for future investigations of the orthographic learning of polysyllabic words. Recall that there is currently one published peer-reviewed study (Tucker et al., 2016) that reported attempts to understand the role of morphology in the acquisition of whole-word representations of polysyllabic words.

As one of the pioneering studies in this area, this study illustrates the challenges of and the considerations that must be taken when designing pseudo-polysyllabic stimuli and thus it serves as a guide for future researchers examining the orthographic learning of polysyllabic words.

5.6 Directions for Future Research

This study serves as the starting point to the examination of the orthographic learning of polysyllabic words. Future studies should aim to replicate the findings of this study using carefully designed stimuli and a larger sample size of children with reading difficulty. Future studies may also include analyses of the patterns in spelling errors and inaccurate orthographic choice selection as well as utilize item-response analyses. Accurate identification of words in the orthographic choice task coupled with spelling errors indicating phonetic spelling and regularization patterns would provide support for Frith's (1986) contention of disassociation between the use of orthographic strategy in reading (word recognition-input) and writing (word production-output) and Perfetti's (2007) lexical quality hypothesis. According to Frith (1986), in alphabetic languages, children may read words using a direct orthographic (lexical) strategy but continue to spell them through an alphabetic strategy, which could result in phonetic spelling or regularization in the case of irregular words. If this disassociation is observed, it will indicate that children have acquired word representations of quality that allowed them to identify the words directly through orthography, but the representations are not at the level of specificity or quality that allow for accurate spelling of the words. Higher quality representations may be just a matter of repetition and practice. One the other hand, the accurate spelling of a word and the inaccurate identification of its form in the orthographic choice task may indicate weak orthographic representations and the accurate spelling is the result of an alphabetic rather than orthographic strategy.

Future research may also utilize item-response analyses to unpack the individual differences in the orthographic learning of polysyllabic words. An increasing number of studies in the field of education psychology is using item-response analysis to overcome the bias that averaged data can produce. According to Andrews (2015),

> Relying on averaged data to evaluate theories reflects an implicit uniformity assumption (Andrews, 2012): that all skilled readers have developed the same cognitive architecture and read in the same way. […] averaged data can obscure systematic individual differences and potentially lead to misleading conclusions about underlying cognitive processes. Rather than modifying models to better fit average patterns of performance, it is time for experimental psycholinguists to consider whether and how individual differences modulate skilled lexical retrieval. (p. 130)

Future research may also examine the effects of morphology using different morphological units (e.g., prefixes) and words with different levels of morphological transparency. Given that word recognition is facilitated by semantic richness (Balota, Ferraro, & Connor, 1991; Pexman, 2012), the inability to identify or access the morphological constituents of a word due to its morphological opacity may decrease the facilitation of the within-word semantic information in the orthographic learning of polysyllabic-polymorphemic words afforded through morphology. If children are unable to identify a word through morphological analysis due to its morphological opacity, they will likely treat it as a pseudoword (Taft, 2015), in which case examining the effects of morphology on the orthographic learning of polysyllabic-polymorphemic words may produce null results. Thus, it is important to examine morphology effects using words with different levels of transparency, which will also provide a guidance for teachers trying to decide on the level of morphological analysis strategy that would be most beneficial for their students.

Finally, future research may examine the orthographic learning of polysyllabic words in a linguistically diverse group of children. Specifically, compare the patterns of orthographic learning of native English-speaking children to that of English language learners of various linguistic background. The research may aim to determine the possible influences of first language on the orthographic learning in English as a second (or additional) language. A group of learners that is of a particular interest to the author of this study is English language learners who are native Arabic speakers. Arabic is a Semitic language characterized by morphological richness—All Arabic words are derivatives from unpronounceable consonantal stems and words are created by adding prefixes, infixes, and suffixes. Arabic is also an alphabetic language that can be represented using a transparent orthography with one-to-one grapheme-phoneme correspondences, or an opaque orthography that omits short vowel markings. While there is converging evidence for the significant contributions of phonological decoding in Arabic word recognition, both transparent and opaque, the role that morphological knowledge plays in Arabic word recognition remains undetermined (Al Ghanem & Kearns, 2015). Given that ELLs' orthographic learning may be influenced by the characteristics of the orthography of their first language, it is compelling to examine factors related to orthographic learning in Arabic and to examine how orthographic learning in Arabic relates to the orthographic learning in English when it is taught as a second language.

5.7 Conclusion

This study is unique in that it is one of the earliest studies examining the orthographic learning of polysyllabic words. While a number of limitations suggest that the findings of this study must be interpreted with caution, it is undeniable that the findings of this study provide strong evidence for the importance of morphology in the acquisition of whole-word representations of polysyllabic words in children with and without reading difficulty. This study also provides strong evidence against utilizing contextual semantic information as a word identification strategy, due to the inhibiting effects of context in the formation of high-quality representations of polysyllabic words, especially for children with reading difficulty.

APPENDICES

Appendix A: Target Word Lists

List 1	**List 2**	**List 3**	**List 4**
vounful	vounness	vounbel	vounrass
foudness	foudbel	foudrass	foudful
lergbel	lergrass	lergful	lergness
beelrass	beelful	beelness	beelbel
yaukful	yaukness	yaukbel	yaukrass
jealness	jealbel	jealrass	jealful
merdbel	merdrass	merdful	merdness
nawlrass	nawlful	nawlness	nawlbel
zeetful	zeetness	zeetbel	zeetrass
roopness	roopbel	rooprass	roopful
zurtbel	zurtrass	zurtful	zurtness
nurkrass	nurkful	nurkness	nurkbel

Appendix B: Context Condition Stories (List 1)

1. My older sister and I made a *yaukful* cake for my mom's birthday party. Everyone at the party liked the cake and said it was very *yaukful*. It was our first time baking and we were happy the cake turned out to be *yaukful*. We told mom we would make it again for her next year.
2. I slipped on the wet floor and sprained my ankle. It was *zurtbel* to walk so I went to the nearby hospital. I explained to the doctor that walking was very *zurtbel*. She examined me and said I had a minor injury. She said, “It might be *zurtbel* now, but the injury will heal in two weeks.”
3. There are many *vounful* flowers in the small garden near my aunt's house. Every time I walk by it, I marvel at how *vounful* the flowers are. I took a picture of them for my school’s art contest. Everyone in the school liked my picture of the *vounful* flowers. My picture won first place.
4. It was Mark’s ninth birthday. His parents surprised him with a gift he had always wanted, a puppy. The puppy was tiny and *merdbel* and Mark was very happy he got it. Having a *merdbel* puppy brings joy to life. Every day after school, Mark took his *merdbel* puppy to the park and played for hours.
5. My brother is very *zeetful*. He buys fabric and makes beautiful clothes. I told him, “You are very *zeetful* and I am not. I wish I could make clothes too.” He replied, “You are very *zeetful* in cooking and I don’t know how to cook; we are all special in our own way.”
6. Sarah likes her *lergbel* car, but it breaks down from time to time. So, Sarah took it to the shop to fix it. When the repairman saw the car, he said, “What a *lergbel* car! Would you sell it to me?” Sarah did not sell her *lergbel* car because it was a gift from her father.
7. We wanted to swim in the pool. My dad told us he needed to check the *jealness* of the water in the pool first. He said that we must check the *jealness*

of the water in the pool before we swim in it. Water *jealness* is important for the health of both humans and animals.

8. A little *beelrass* brightens everyone's day. On my way to the park, I saw an elderly man carrying heavy bags and trying to cross the street. I helped him with his bags and he thanked me for my *beelrass*. He said that he had a tough morning and that my *beelrass* made his day.
9. Runners need to have a high level of *roopness* so they can compete in races. To reach a high level of *roopness*, they have to train daily. You see them running outdoors even when it is cold or raining. If they stop training, their level of *roopness* will drop. If that happens, they may get injured.
10. Nora bought a new leather chair. She chose it because she likes the *nurkrass* of leather. She asked her mom how to care for it. She learned harsh cleaners could damage the *nurkrass* of the leather. She also learned she must use good leather conditioner every 6 to 12 months to maintain its *nurkrass*.
11. We learned about animals known for their *foudness* in school. One such animal is the lion. Because of their *foudness*, lions sleep 18 to 20 hours a day. Lions' *foudness* is linked to the warm climates they live in. On a hot day in Africa, lions can sleep up to 24 hours a day.
12. Did you know that the time needed to cook a steak depends on its *nawlrass*? You need to consider the steak's *nawlrass* so you don't over or undercook it. For a steak of normal *nawlrass*, you must grill it for 10 minutes then flip it and cook for 8 more minutes to make sure it's done.

Appendix C: Isolation Condition-Real Words

1. get
2. leather
3. dad
4. mom
5. lion
6. cold
7. important
8. depends
9. sprained
10. use
11. wish
12. likes
13. down
14. joy
15. cooking
16. fabric
17. elderly
18. breaks
19. flip
20. might
21. went
22. sure
23. animals
24. needed
25. carrying
26. cleaners
27. bags
28. heal
29. happy
30. learned
31. hot
32. could
33. good
34. minor
35. linked
36. also
37. small
38. contest
39. from
40. happens
41. little
42. level
43. daily
44. asked
45. very
46. played
47. normal
48. chose
49. flowers
50. turned
51. house
52. must
53. gift
54. slipped
55. told
56. many
57. walk
58. birthday
59. buys
60. saw
61. man
62. more
63. art
64. pool
65. party
66. cross
67. ankle
68. Everyone
69. injured
70. trying
71. hours
72. see

Appendix D: Orthographic Choice Task

List 1 Items

	Target	HF	VD	VDH
1.	vounful	vownful	voumful	vowmful
2.	foudness	fowdness	toudness	towdness
3.	lergbel	lurgbel	fergbel	furgbel
4.	beelrass	bealrass	lealrass	leelrass
5.	yaukful	yawkful	vawkful	vaukful
6.	jealness	jeelness	yealness	yeelness
7.	merdbel	murdbel	merpbel	murpbel
8.	nawlrass	naulrass	nawtrass	nautrass
9.	zeetful	zeatful	zeedful	zeadful
10.	roopness	rewpness	noopness	newpness
11.	zurtbel	zertbel	surtbel	sertbel
12.	nurkrass	nerkrass	nurlrass	nerlrass

Note. HF = Homophone foil; VD = Visual distractor;
VDH = Visual distractor's homophone

Randomized List 1 Items

1.	jeelness	yealness	jealness	yeelness
2.	lergbel	furgbel	lurgbel	fergbel
3.	yawtful	yautful	yaukful	yawkful
4.	nerkrass	nerlrass	nurkrass	nurlrass
5.	roapness	noopness	roopness	noapness
6.	zeadful	zeedful	zeatful	zeetful
7.	murpbel	murdbel	merdbel	merpbel
8.	naulrass	nautrass	nawtrass	nawlrass
9.	lealrass	leelrass	bealrass	beelrass
10.	vowmful	vounful	vownful	voumful
11.	towdness	foudness	fowdness	toudness
12.	surtbel	zertbel	zurtbel	sertbel

List 2 Items

	Target	HF	VD	VDH
1.	vounness	vownness	voumness	vowmness
2.	foudbel	fowdbel	toudbel	towdbel
3.	lergrass	lurgrass	fergrass	furgrass
4.	beelful	bealful	lealful	leelful
5.	yaukness	yawkness	vawkness	vaukness
6.	jealbel	jeelbel	yealbel	yeelbel
7.	merdrass	murdrass	merprass	murprass
8.	nawlful	naulful	nawtful	nautful
9.	zeetness	zeatness	zeedness	zeadness
10.	roopbel	rewpbel	noopbel	newpbel
11.	zurtrass	zertrass	surtrass	sertrass
12.	nurkful	nerkful	nurlful	nerlful

Note. HF = Homophone foil; VD = Visual distractor;
VDH = Visual distractor's homophone

Randomized List 2 Items

1.	yautness	yawtness	yaukness	yawkness
2.	vowmness	voumness	vounness	vownness
3.	murdrass	murprass	merprass	merdrass
4.	surtrass	sertrass	zertrass	zurtrass
5.	toudbel	foudbel	towdbel	fowdbel
6.	lurgrass	furgrass	lergrass	fergrass
7.	zeatness	zeetness	zeedness	zeadness
8.	noopbel	roopbel	noapbel	roapbel
9.	jealbel	jeelbel	yeelbel	yealbel
10.	nawtful	nawlful	nautful	naulful
11.	nurkful	nerlful	nerkful	nurlful
12.	leelful	beelful	bealful	lealful

List 3 Items

	Target	HF	VD	VDH
1.	vounbel	vownbel	voumbel	vowmbel
2.	foudrass	fowdrass	toudrass	towdrass
3.	lergful	lurgful	fergful	furgful
4.	beelness	bealness	lealness	leelness
5.	yaukbel	yawkbel	vawkbel	vaukbel
6.	jealrass	jeelrass	yealrass	yeelrass
7.	merdful	murdful	merpful	murpful
8.	nawlness	naulness	nawtness	nautness
9.	zeetbel	zeatbel	zeedbel	zeadbel
10.	rooprass	rewprass	nooprass	newprass
11.	zurtful	zertful	surtful	sertful
12.	nurkness	nerkness	nurlness	nerlness

Note. HF = Homophone foil; VD = Visual distractor;
VDH = Visual distractor's homophone

Randomized List 3 Items

1.	fergful	furgful	lergful	lurgful
2.	yautbel	yaukbel	yawtbel	yawkbel
3.	zeadbel	zeatbel	zeetbel	zeedbel
4.	vowmbel	voumbel	vownbel	vounbel
5.	jealrass	jeelrass	yeelrass	yealrass
6.	rooprass	nooprass	roaprass	noaprass
7.	zertful	sertful	zurtful	surtful
8.	fowdrass	toudrass	foudrass	towdrass
9.	bealness	beelness	lealness	leelness
10.	merpful	merdful	murdful	murpful
11.	naulness	nautness	nawtness	nawlness
12.	nurkness	nerkness	nurlness	nerlness

List 4 Items

	Target	HF	VD	VDH
1.	vounrass	vownrass	voumrass	vowmrass
2.	foudful	fowdful	toudful	towdful
3.	lergness	lurgness	fergness	furgness
4.	beelbel	bealbel	lealbel	leelbel
5.	yaukrass	yawkrass	vawkrass	vaukrass
6.	jealful	jeelful	yealful	yeelful
7.	merdness	murdness	merpness	murpness
8.	nawlbel	naulbel	nawtbel	nautbel
9.	zeetrass	zeatrass	zeedrass	zeadrass
10.	roopful	rewpful	noopful	newpful
11.	zurtness	zertness	surtness	sertness
12.	nurkbel	nerkbel	nurlbel	nerlbel

Note. HF = Homophone foil; VD = Visual distractor;
VDH = Visual distractor's homophone

Randomized List 4 Items

1.	zeetrass	zeedrass	zeadrass	zeatrass
2.	yaukrass	yautrass	yawkrass	yawtrass
3.	murpness	merpness	merdness	murdness
4.	nerkbel	nurlbel	nerlbel	nurkbel
5.	naulbel	nawlbel	nautbel	nawtbel
6.	lergness	fergness	furgness	lurgness
7.	voumrass	vowmrass	vownrass	vounrass
8.	beelbel	bealbel	lealbel	leelbel
9.	noopful	roopful	noapful	roapful
10.	zertness	surtness	zurtness	sertness
11.	fowdful	toudful	towdful	foudful
12.	yealful	yeelful	jealful	jeelful

Appendix E: Carlise's (2000) Test of Morphological Structure- Part 1-Derivation

1. warm.	He chose the jacket for its ____________________.
2. teach.	He was a very good ____________________.
3. permit.	Father refused to give ____________________.
4. profit.	Selling lemonade in summer is ____________________.
5. appear.	He cared about his ____________________.
6. express.	"OK" is a common ____________________.
7. four.	The cyclist came in ____________________.
8. remark.	The speed of the car was ____________________.
9. protect.	She wore glasses for ____________________.
10. perform.	Tonight is the last ____________________.
11. expand.	The company planned an ____________________.
12. revise.	This paper is his second ____________________.
13. reason.	Her argument was quite ____________________.
14. major.	He won the vote by a ____________________.
15. deep.	The lake was well known for its ____________________.
16. equal.	Boys and girls are treated with ____________________.
17. long.	They measured the ladder's ____________________.
18. adventure.	The trip sounded ____________________.
19. absorb.	She chose the sponge for its ____________________.
20. active.	He tired after so much ____________________.
21. swim.	She was a strong ____________________.
22. human.	The kind man was known for his ____________________.
23. wash.	Put the laundry in the ____________________.
24. humor.	The story was quite ____________________.
25. assist.	The teacher will give you ____________________.
26. mystery.	The dark glasses made the man look ____________________.
27. produce.	The play was a grand ____________________.
28. glory.	The view from the hill top was ____________________.

Appendix F: Mitchell and Brady's (2014) Affix Knowledge Test

F.1: Part 1-Suffix Knowledge-Real Words

1. Do you think the word '**warmish**' means:
    a) Very warm
    b) A little cold
    c) Kind of warm
2. What do you think the word '**causeless**' means?
    a) A result that happened without a reason
    b) A consequence of someone's actions
    c) Not important
3. What do you think the word '**likelihood**' means?
    a) The top of a fancy robe that others admire
    b) How much of a chance there is that something will happen
    c) Being certain that something will happen
4. What do you think the word '**climatology**' means?
    a) Techniques for climbing
    b) When the climate changes over time
    c) The study of the climate
5. What do you think the word '**forceful**' means?
    a) Strong
    b) Lengthy
    c) Weak
6. Do you think the word '**authorship**' means:
    a) The activity of writing books or poems
    b) A collection of books or poems
    c) When a person who writes has a boat
7. What do you think the word '**historian**' means?
    a) A book describing the main events that happened in the past
    b) A person who studies what happened in the past
    c) Being like something from the past

8. Do you think the word ‘**thunderous**’ means:

    a) Loud like thunder
    b) Rain clouds
    c) Able to make thunder

9. What do you think the word ‘**notable**’ means?

    a) Writing something down
    b) Something that is unusual or special
    c) Something that is ordinary or typical

10. What do you think the word ‘**betterment**’ means?

    a) When a person bets on something
    b) A mint that is especially tasty
    c) Improving something

11. Do you think the word '**crystallize**’ means:

    a) To be like a crystal
    b) To turn something into crystals
    c) To believe in the power of crystals

12. Which of these descriptions represents the word ‘**blockage**’?

    a) A football player running to catch a pass
    b) A tall tower of blocks falling on the floor
    c) A group of cars stopped across the road

13. What do you think the word ‘**activist**’ means?

    a) A machine that has lots of movement when it is on
    b) A person who works to change things in society in good ways
    c) An army fighting against the enemy

14. Which of these descriptions best fits the word ‘**closure**’?

    a) A person who is responsible for the clothes of kings and queens
    b) When textbooks have the answers to questions at the back of the book
    c) The feeling that something important in life has come to an end

15. Do you think the word ‘**thicken**’ means:

    a) To increase the thickness of something
    b) A measurement of thickness
    c) To decrease the thickness of something

16. What do you think the word '**centrality**' means?

    a) To move away from the center
    b) To be at the center
    c) To move in a circle motion

F.2: Part 2-Prefix Knowledge-Real Words

1. Do you think the word ‘**unclean**’ means:
   a) Full of soap
   b) Dirty
   c) Not dirty
2. Do you think the word ‘**befriend**’ means:
   a) Someone who takes care of bees and beehives
   b) To meet someone again after you haven't seen them for a long time
   c) To get to know someone and share things with him
3. Which of these things could be described as a ‘**monotone**’?
   a) When a person's voice is always at one level
   b) When a song is sung by two singers
   c) When a person's voice goes up and down
4. Which of these pairs of things would best be described as a ‘**mismatch**’?
   a) A yellow sock and another yellow sock
   b) Pancakes and syrup
   c) A black shoe and a green shoe
5. Which of these things could best be described as ‘**interoffice**’?
   a) Offices in different countries
   b) Sharing or using things within the same office
   c) Sharing or sending between different offices
6. Do you think the word ‘**antihero**’ means:
   a) A person in a book who rescues others
   b) A person in a book who is mean to others or selfish
   c) A person in a book who has unusual superpowers
7. Do you think the word ‘**disvalue**’ means:
   a) To figure out what something is worth
   b) To think something is worth less than you used to think it was worth
   c) To insult someone during an argument
8. Which of these situations could be described by the word ‘**malpractice**’?
   a) When a doctor harms his patients
   b) When a teacher reads to her students every day
   c) When a person accidentally steps on his friend's foot

9. Do you think the word ‘**entrust**’ means:
    a) A bank or large safe
    b) To give something to a person for protection
    c) To think someone is not being honest
10. What do you think a ‘**multifamily**’ home is?
    a) A home that only one family lives in
    b) A home that a family has lived in at many different times
    c) A home that many families live in at the same time
11. Do you think the word ‘**postwar**’ means;
    a) Before a war
    b) After a war
    c) Mail sent during a war
12. What do you think the word ‘**rediscover**’ means?
    a) To find something again
    b) To find something for the first time
    c) To hide something from view
13. Which of these describes the meaning of the word ‘**transplant**’?
    a) To move a bush from one place to another place
    b) To help a flower grow by giving it soil and water
    c) A tree that grows both in the forest and the desert
14. Do you think the word ‘**coexist**’ means:
    a) To live in peace with others
    b) To leave a room with another person
    c) To live quietly by yourself
15. What do you think the word ‘**substandard**’ means?
    a) Above a standard
    b) At a standard
    c) Below a standard
16. Which of these fits with the word ‘**insecure**’?
    a) Feeling confident and strong
    b) Feeling anxious and uncertain
    c) Feeling like a bug

F.3: Part 3-Suffix Knowledge-Pseudowords

A.'*Mox*' is a made-up word that means '*smooth*.'

A1. Which of these made-up words could mean '**possible to smooth out**?

a). moxist b). moxable c). moxful

A2. If '*mox*' means '*smooth',* which word could mean to **'make smooth'**?

a). moxian b). moxous c). moxen

A3.Which could mean '**kind of smooth'** ?

a). moxish b). moxship c). moxize

A4. Which could mean '**being in a group of things that all can be described as smooth'**?

a). moxless b). moxhood c). moxology

B. '*Plip*' is a made-up word that means '*hope*.'

B1. Which of these made-up words do you think could mean '**full of hope'**?

a). plipish b). plipility c). plipous

B2. If '*plip*' means '*hope*', which word could mean '**having the quality of being hopeful'**?

a). plipen b). plipize c). plipship

B3. Which could mean '**without hope'**?

a). plipure b). plipless c). plipage

C. '*Dort*' is a made-up word that means '*to stop*.'

C1. Which of these made-up words could mean '**the result of being stopped'**?

a). dortment b). dortist c). dortless

C2. If '*dort*' means '*to stop*', which word could mean '**the act of stopping**'?

a). dortish b). dortful c). dorture

C3. Which could mean '**how much something is getting stopped**?

a). dortage b). dortian c). dortology

D. '*Roonil*' is a made-up word that means '*special*.'

D1. Which of these made-up words could mean '**a person who is special'**?

a). roonilist b). roonilable c). roonilous

D2. If '*roonil*' means '*special*', which word could mean '**to make into something special'**?

a). roonilship b). roonilize c). roonilhood

D3. Which could mean '**a way of being special'**?

a). roonility b). roonilen c). roonilment

E. '*Flur*' is a made-up word that means '*space.*'

E1. Which of these words do you think could mean '**a person who is from space'**?

a). flurable b). flurian c). flurhood

E2. If '*flur*' means '*space*', which word could mean '**filled with space'**?

a). flurment b). flurage c). flurful

E3. Which could mean '**the study of space**?

a). flurology b). flurure c). flurility

F.4: Part 4-Prefix Knowledge-Pseudowords

A. '*Splin*' is a made-up word that means '*to learn.*'

A1. Which of these made-up words do you think could mean '**not learned**'?
a). multisplinned b). unsplinned c). subsplinned

A2. If '*splin*' means '*to learn*', which word could mean '**to learn again'**?
a). monosplin b). insplin c). resplin

A3. Which word could mean '**to learn after'**?
a). postsplin b). ensplin c). dissplin

A4. Which word could mean '**against learning'**?
a). malsplinning b). antisplinning c). besplinning

B. '*Jort*' is a made-up word that means a '*thought.*'

B1. Which of these made-up words do you think could mean '**one thought'**?
a). monojort b). enjort c). misjort

B2. If '*jort*' means '*thought*', which word could mean '**evil thoughts'**?
a). transjorts b). antijorts c). maljorts

B3. Which could mean '**many thoughts'**?
a). cojorts b). multijorts c). disjorts

B4. Which could mean '**not having a thought**'?
a). injort b). subjort c). postjort

C. '*Glick*' is a made-up word that means '*to hide.*'

C1. Which of these made-up words could mean '**to hide with another person**'?
a). unglick b). coglick c). transglick

C2. If '*glick*' means '*to hide*', which word could mean '**the opposite of hiding**'?
a). malglicking b). interglicking c). disglicking

C3. Which could mean '**to hide under something'**?
a). reglick b). monoglick c). subglick

C4. Which could mean '**to hide badly'**?
a). misglick b). beglick c). multiglick

D. '*Lanost*' is a made-up word that means '*forest.*'

D1. Which of these made-up words do you think could mean '**across the forest'**?
a). unlanost b). colanost c). translanost

D2. If '*lanost*' means '*forest*', which word could mean '**between forests'**?
a). mislanosts b). interlanosts c). antilanosts

D3. Which could mean ‘**completely forested’**?

a). belanosted | b). relanosted | c). inlanosted

D4. Which could mean ‘**to put into the forest’**?

a). postlanost | b). interlanost | c). enlanost

Appendix G: Olson et al.'s (1985) Orthographic Choice Task

1.	goat	gote	34.	example	exsample
2.	wize	wise	35.	wagun	wagon
3.	nuisance	nusance	36.	deep	deap
4.	wheat	wheet	37.	believe	beleave
5.	distance	distence	38.	goast	ghost
6.	liberty	libberty	39.	hurt	hert
7.	true	trew	40.	travel	travle
8.	sammon	salmon	41.	sensitive	sensative
9.	importent	important	42.	compliment	complimant
10.	anser	answer	43.	condence	condense
11.	smoke	smoak	44.	sevral	several
12.	resourse	resource	45.	mystery	mysterey
13.	grone	grown	46.	deamon	demon
14.	explane	explain	47.	store	stoar
15.	few	fue	48.	captain	captin
16.	streem	stream	49.	skait	skate
17.	toward	toard	50.	streat	street
18.	salad	sallad	51.	studdy	study
19.	roar	rore	52.	easy	eazy
20.	ashure	assure	53.	aplause	applause
21.	nostrils	nostrels	54.	wreath	reath
22.	coat	cote	55.	baisment	basement
23.	purched	perched	56.	senaters	senators
24.	wait	wate	57.	suddin	sudden
25.	faught	fought	58.	pavemant	pavement
26.	thum	thumb	59.	dream	dreem
27.	between	betwean	60.	tape	taip
28.	backwards	backwords	61.	every	evry
29.	scare	scair	62.	interesting	intresting
30.	engine	anjine	63.	alternative	alternitive
31.	dignity	dignaty	64.	muscle	mussle
32.	culpret	culprit	65.	trowsers	trousers
33.	hearth	harth			

Appendix H: Cassar and Treiman's (1997) Letter String Task

1.	boap	bowp
2.	wibz	wibs
3.	jeex	jeeks
4.	fage	fayj
5.	qoast	quost
6.	lape	laip
7.	holp	hollp
8.	vose	voaz
9.	Ym	phim
10.	booce	buice
11.	furb	Wrb
12.	nurm	nerm
13.	hoin	hoyn
14.	toove	tuve
15.	lerst	lurst
16.	dilk	dilc
17.	glick	glyck
18.	cleyd	cleed
19.	lasp	lassp
20.	dayk	dake
21.	vosst	vost
22.	sckap	skap
23.	showk	shoke
24.	prant	prahnt
25.	llyth	lith
26.	splot	spliut
27.	squyt	squit
28.	sthrud	strud
29.	thram	trham
30.	sprad	srpad

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